Ch. 2 Loops

```
int counter{ 1 };
cout << counter << ' ';
++counter;
cout << counter << ' ';
++counter;
cout << counter << ' ';
++counter;
cout << counter << ' ';
++counter;</pre>
cout << endl;
```

```
int counter{ 1 };
cout << counter << ' ';
++counter;
cout << endl;</pre>
```

```
int counter{ 1 };
cout << counter << ' ';
++counter;
cout << endl;</pre>
```



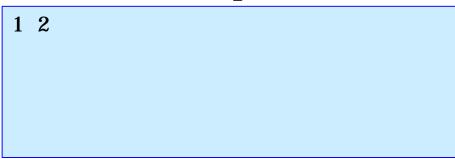
```
int counter{ 1 };
cout << counter << ' ';
++counter;
cout << endl;</pre>
```



```
int counter{ 1 };
cout << counter << ' ';
++counter;
cout << endl;</pre>
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```
int counter{ 1 };
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```
int counter{ 1 };
cout << counter << ' ';
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```



```
int counter{ 1 };
cout << counter << ' ';
++counter;
cout << endl;</pre>

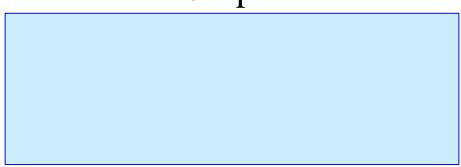
0012FF7D
0012FF7E
0012FF7F
```



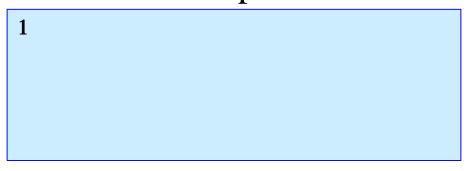
```
int counter{ 1 };
cout << counter << ' ';
++counter;
cout << endl;</pre>

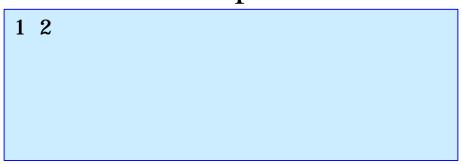
0012FF7D
0012FF7E
0012FF7F
```













```
1 2 3
```





```
#include <iostream>
using namespace std;

int main()
{
   for( int counter{ 1 }; counter <= 10; ++counter )
      cout << counter << ' ';

   cout << endl;
}</pre>
```

```
int counter{ 1 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
counter

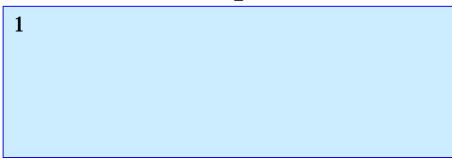
0012FF7C
0012FF7D
0012FF7E
0012FF7F
```

```
int counter{ 1 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
counter

0012FF7C
0012FF7D
0012FF7E
0012FF7F
```

```
int counter{ 1 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
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cout << endl;</pre>
counter

0012FF7C
0012FF7D
0012FF7E
0012FF7F
```



```
int counter{ 1 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
counter

0012FF7C
0012FF7D
0012FF7E
0012FF7F
```



```
int counter{ 1 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
counter

0012FF7C
0012FF7D
0012FF7E
0012FF7F
```



```
int counter{ 1 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
counter

0012FF7C
0012FF7D
0012FF7E
0012FF7F
```



```
int counter{ 1 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
oon12FF7C
0012FF7D
0012FF7E
0012FF7F
```

```
1 2 3
```

```
int counter{ 1 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
counter

0012FF7C
0012FF7D
0012FF7E
0012FF7F
```

```
1 2 3
```

```
int counter{ 1 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
counter

0012FF7C
0012FF7D
0012FF7E
0012FF7F
```

```
1 2 3
```

```
#include <iostream>
using namespace std;
int main()
{
   int counter{ 1 };
   while( counter <= 10 )</pre>
       cout << counter << ' ';</pre>
       ++counter;
   cout << endl;</pre>
```

```
int counter{ 1 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;</pre>
0012FF7C
0012FF7D
0012FF7F
```

```
int counter{ 1 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;

0012FF7C
0012FF7D
0012FF7F</pre>
```

```
int counter{ 1 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;

0012FF7C
0012FF7D
0012FF7E
0012FF7F</pre>
```



```
int counter{ 1 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;

0012FF7C
0012FF7D
0012FF7E
0012FF7F</pre>
```



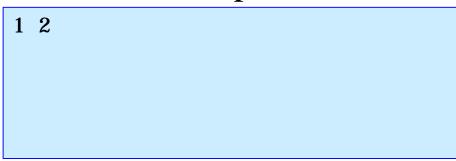
```
int counter{ 1 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;

0012FF7C
0012FF7D
0012FF7F</pre>
```



```
int counter{ 1 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;

0012FF7C
0012FF7D
0012FF7F</pre>
```



```
int counter{ 1 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;

0012FF7C
0012FF7D
0012FF7E
0012FF7F</pre>
```

```
1 2 3
```

```
int counter{ 1 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;

0012FF7C
0012FF7D
0012FF7F</pre>
```

```
1 2 3
```

```
int counter{ 1 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;

0012FF7C
0012FF7D
0012FF7F</pre>
```

```
1 2 3
```

```
#include <iostream>
using namespace std;
int main()
   int counter{ 1 };
   do
       cout << counter << ' ';</pre>
       ++counter;
   } while( counter <= 10 );</pre>
   cout << endl;</pre>
```

For Statements

```
for( int counter{ 4 }; counter <= 3; ++counter )
  cout << counter << ' ';</pre>
```

counter 0012FF7C 0012FF7D 0012FF7E 0012FF7F

For Statements

```
for( int counter{ 4 }; counter <= 3; ++counter )
  cout << counter << ' ';</pre>
```

counter 4 0012FF7C 0012FF7D 0012FF7E 0012FF7F

```
int counter{ 4 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
counter

0012FF7C
0012FF7D
0012FF7E
0012FF7F
```

```
int counter{ 4 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
counter

onumber 0012FF7C

onumber 4

onumber 0012FF7E

onumber 1

onumber 1

onumber 2

onumber 3

onumber 2

onumber 3

onumber 3

onumber 3

onumber 4

onumber
```

```
int counter{ 4 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
counter

onumber 0012FF7C

onumber 4

onumber 0012FF7E

onumber 1

onumber 1

onumber 2

onumber 3

onumber 2

onumber 3

onumber 3

onumber 3

onumber 4

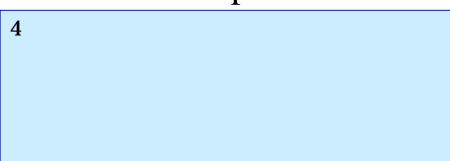
onumber
```

```
int counter{ 4 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;</pre>
0012FF7C
0012FF7D
0012FF7F
```

```
int counter{ 4 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;</pre>
counter

0012FF7D
0012FF7D
0012FF7F
```

```
int counter{ 4 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;</pre>
0012FF7C
0012FF7D
0012FF7F
```



```
int counter{ 4 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;</pre>
0012FF7C
0012FF7D
0012FF7F
```



```
int counter{ 4 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;</pre>
0012FF7C
0012FF7D
0012FF7F
```



Comparison

```
for( int counter{ 1 }; counter <= 3; ++counter )
  cout << counter << ' ';
cout << endl;</pre>
```

```
int counter{ 1 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
```

```
int counter{ 1 };
do {
   cout << counter << ' ';
   ++counter;
} while( counter <= 3 );
cout << endl;</pre>
```

for Repetition Statement

• The for statement looks pretty simple in abstract:

```
for( init-statement; condition; end-expression )
   statement;
```

- It is possible to write for loops that omit any or all of the statements or expressions.
- An omitted condition-expression in a for loop should be treated as true.
- One might omit the init-statement if the control variable is initialized earlier in the program.
- One might omit the end-expression if the increment is calculated by statements in the body of the for or if no increment is needed.

```
#include <iostream>
using namespace std;

int main()
{
   for( int counter{ 1 }; counter <= 10; ++counter )
        cout << counter << ' ';

   cout << endl;
}</pre>
```

for Repetition Statement

The three expressions in the for statement header are optional.

```
for( int counter{ 1 }; counter <= 3; ++counter )
   cout << counter << ' ';
cout << endl;</pre>
```

```
int counter{ 1 };
while( counter <= 3 )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
```

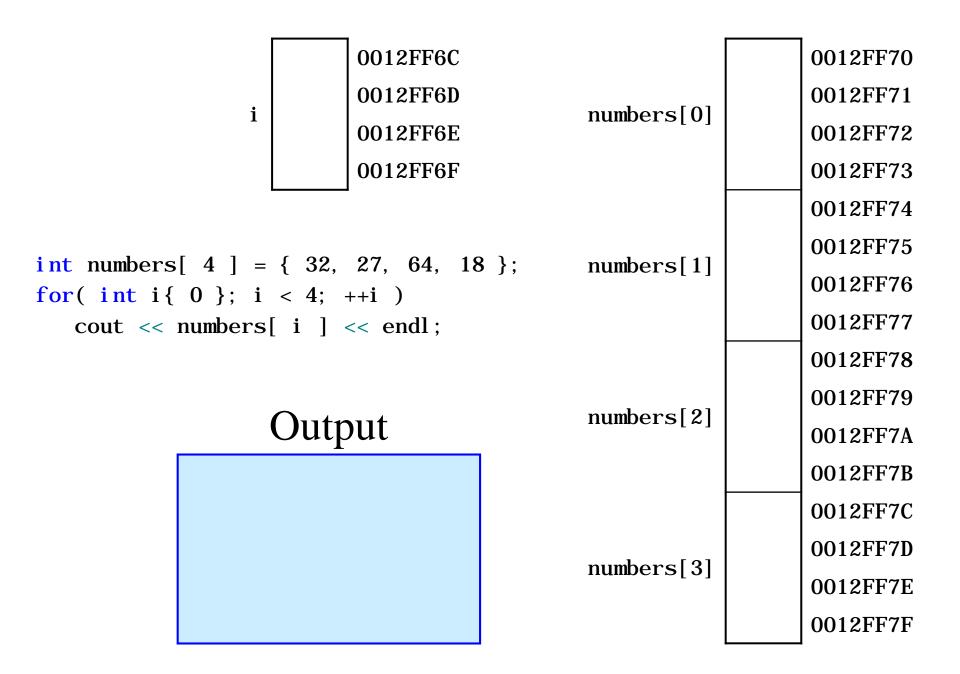
```
int counter{ 1 };
for(; counter <= 3; )
{
    cout << counter << ' ';
    ++counter;
}
cout << endl;</pre>
```

Examples Using the for Statement

```
for( int i { 1 }; i <= 100; i++ )
for( int i = { 100 }; i >= 1; i-- )
for( int i = { 7 }; i <= 77; i += 7 )
for( int i = { 20 }; i >= 2; i -= 2 )
for( int i = { 2 }; i <= 20; i += 3 )
for( int i = { 99 }; i >= 0; i -= 11 )
```

```
#include <iostream>
#include <iomanip>
using namespace std;

int main()
{
   int numbers[ 4 ] = { 32, 27, 64, 18 };
   cout << "Index" << setw( 7 ) << "Value" << endl;
   for( int i{ 0 }; i < 4; ++i )
      cout << setw( 5 ) << i << setw( 7 ) << numbers[ i ] << endl;
}</pre>
```



	i	0012FF6C 0012FF6D 0012FF6E 0012FF6F	numbers[0]	32	0012FF70 0012FF71 0012FF72 0012FF73
<pre>for(int i{</pre>	0 }; i <	32, 27, 64, 18 4; ++i)] << endl;	}; numbers[1]	27	0012FF74 0012FF75 0012FF76 0012FF77
	Oı	ıtput	numbers[2]	64	0012FF78 0012FF79 0012FF7A 0012FF7B
			numbers[3]	18	0012FF7C 0012FF7D 0012FF7E 0012FF7F

	i	0	0012FF6C 0012FF6D 0012FF6E 0012FF6F	numbers[0]	32	0012FF70 0012FF71 0012FF72 0012FF73
<pre>int numbers for(int i{ cout << ;</pre>	0 }; i	< 4;	++ i)	}; numbers[1]	27	0012FF74 0012FF75 0012FF76 0012FF77
		Outp	out	numbers[2]	64	0012FF78 0012FF79 0012FF7A 0012FF7B
				numbers[3]	18	0012FF7C 0012FF7D 0012FF7E 0012FF7F

	i	0	0012FF6C 0012FF6D 0012FF6E 0012FF6F	numbers[(0] 32	0012FF70 0012FF71 0012FF72 0012FF73
<pre>int numbers for(int i{ cout << !</pre>	0 }; i	< 4;	++ i)	; numbers[1	27	0012FF74 0012FF75 0012FF76 0012FF77
	32	Outp	out	numbers[2	2] 64	0012FF78 0012FF79 0012FF7A 0012FF7B
				numbers[3	3] 18	0012FF7C 0012FF7D 0012FF7E 0012FF7F

	i	1	0012FF6C 0012FF6D 0012FF6E 0012FF6F	numbers[0]	32	0012FF70 0012FF71 0012FF72 0012FF73
<pre>int numbers for(int i{ cout << :</pre>	0 }; i	< 4;	++i)	numbers[1]	27	0012FF74 0012FF75 0012FF76 0012FF77
	32	Outp	out	numbers[2]	64	0012FF78 0012FF79 0012FF7A 0012FF7B
				numbers[3]	18	0012FF7C 0012FF7D 0012FF7E 0012FF7F

	i	1	0012FF6C 0012FF6D 0012FF6E 0012FF6F	numbers	[0] 32	0012FF70 0012FF71 0012FF72 0012FF73
<pre>int numbers for(int i{ cout << 1</pre>	0 }; i	< 4;	++i)	ß}; numbers	[1] 27	0012FF74 0012FF75 0012FF76 0012FF77
	32	Outp	out	numbers	[2] 64	0012FF78 0012FF79 0012FF7A 0012FF7B
	27			numbers	[3] 18	0012FF7C 0012FF7D 0012FF7E 0012FF7F

	i	2	0012FF6C 0012FF6D 0012FF6E 0012FF6F	r	numbers[0]	32	0012FF70 0012FF71 0012FF72 0012FF73
<pre>int numbers[for(int i{ (cout << numbers)</pre>	0 }; i	< 4;	++i)	3 }; r	numbers[1]	27	0012FF74 0012FF75 0012FF76 0012FF77
	32	Outp	out	r	numbers[2]	64	0012FF78 0012FF79 0012FF7A 0012FF7B
	27			r	numbers[3]	18	0012FF7C 0012FF7D 0012FF7E 0012FF7F

	i	2	0012FF6C 0012FF6D 0012FF6E 0012FF6F	nun	nbers[0]	32	0012FF70 0012FF71 0012FF72 0012FF73
<pre>int numbers[for(int i{ cout << r.</pre>	0 }; i	< 4;	++i)	3 }; num	bers[1]	27	0012FF74 0012FF75 0012FF76 0012FF77
	32	Outp	out	nun	bers[2]	64	0012FF78 0012FF79 0012FF7A 0012FF7B
	27 64			nun	bers[3]	18	0012FF7C 0012FF7D 0012FF7E 0012FF7F

	i	3	0012FF6C 0012FF6D 0012FF6E 0012FF6F		numbers[0]	32	0012FF70 0012FF71 0012FF72 0012FF73
<pre>int numbers[for(int i{ cout << r.</pre>	0 }; i	< 4;	++i)	3 };	numbers[1]	27	0012FF74 0012FF75 0012FF76 0012FF77
	32	Outp	out		numbers[2]	64	0012FF78 0012FF79 0012FF7A 0012FF7B
	27 64				numbers[3]	18	0012FF7C 0012FF7D 0012FF7E 0012FF7F

	i	3	0012FF6C 0012FF6D 0012FF6E 0012FF6F	numbers[0] 32	0012FF70 0012FF71 0012FF72 0012FF73
<pre>int numbers[for(int i{ cout << n</pre>	0 }; i	< 4;	++ i)	3 }; numbers[1] 27	0012FF74 0012FF75 0012FF76 0012FF77
	32	Outp	out	numbers[2] 64	0012FF78 0012FF79 0012FF7A 0012FF7B
	27 64 18			numbers[3] 18	0012FF7C 0012FF7D 0012FF7E 0012FF7F

	i	4	0012FF6C 0012FF6D 0012FF6E 0012FF6F	numbe	ers[0]	32	0012FF70 0012FF71 0012FF72 0012FF73
<pre>int numbers[for(int i{ cout << n</pre>	0 }; i	< 4;	++ i)	3}; numbe	ers[1]	27	0012FF74 0012FF75 0012FF76 0012FF77
	32	Outp	out	numbe	ers[2]	64	0012FF78 0012FF79 0012FF7A 0012FF7B
	27 64 18			numbe	ers[3]	18	0012FF7C 0012FF7D 0012FF7E 0012FF7F

Index	Val ue
0	32
1	27
2	64
3	18

const variable

```
#include <iostream>
using namespace std;

int main()
{
   const int number{ 10 };
   cout << number << endl;
}</pre>
```

const variable

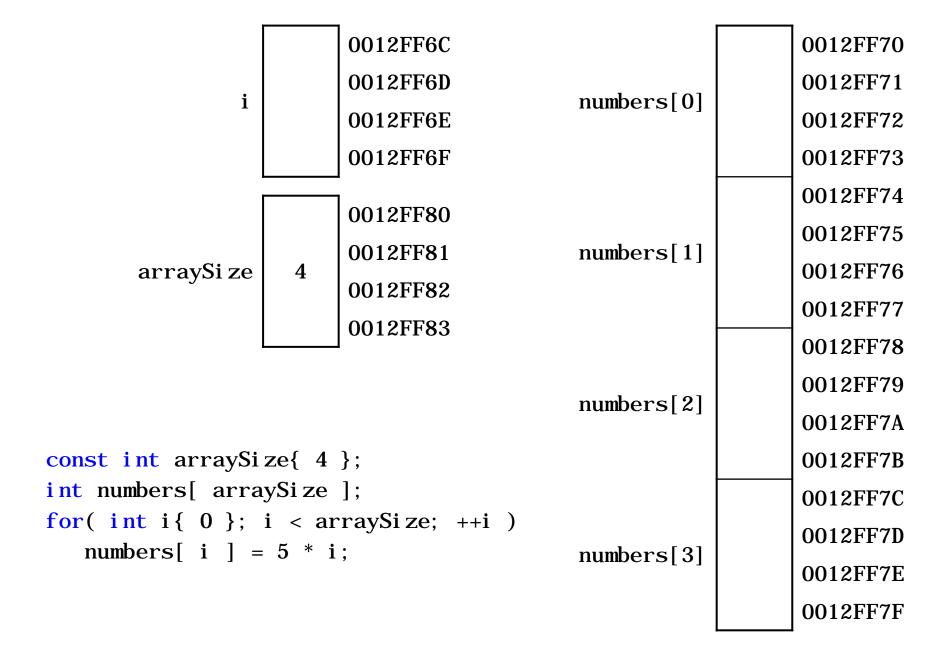
```
#include <iostream>
using namespace std;
int main()
{
   const int number; // Error: number must be initialized
}
```

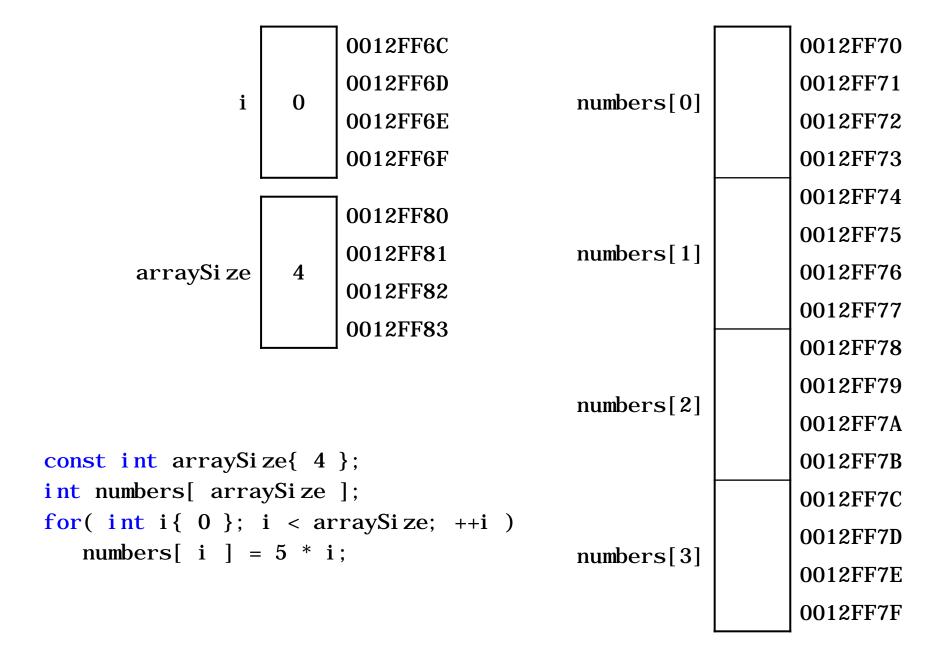
const variable

```
#include <iostream>
using namespace std;

int main()
{
   const int number{ 10 };
   number = 20; // Error: cannot modify a const variable
}
```

```
#include <iostream>
#include <i omanip>
using namespace std;
int main()
   const int arraySize{ 4 };
   int numbers[ arraySize ];
   for( int i{ 0 }; i < arraySize; ++i )</pre>
      numbers[i] = 5 * i;
   cout << "Index" << setw( 7 ) << "Value" << endl;</pre>
   for( int i{ 0 }; i < arraySize; ++i )</pre>
      cout << setw( 5 ) << i << setw( 7 ) << numbers[ i ] << endl;</pre>
```





i		0012FF6C	numb on a [O]		0012FF70
	0	0012FF6D		0	0012FF71
	U	0012FF6E	numbers[0]	U	0012FF72
		0012FF6F			0012FF73
		0012FF80			0012FF74
arraySi ze		0012FF81	numbers[1]		0012FF75
	4	0012FF81 0012FF82			0012FF76
		0012FF82 0012FF83			0012FF77
		00127763			0012FF78
			numb and [9]		0012FF79
			numbers[2]		0012FF7A
<pre>const int arraySi</pre>	ze{ 4	} ;			0012FF7B
int numbers[arra	•				0012FF7C
<pre>for(int i{ 0 }; numbers[i] -</pre>		ŭ			0012FF7D
<pre>numbers[i] = 5 * i;</pre>			numbers[3]		0012FF7E
					0012FF7F

i		0012FF6C	h [0]	0	0012FF70
	1	0012FF6D			0012FF71
	1	0012FF6E	numbers[0]	U	0012FF72
		0012FF6F			0012FF73
		0012FF80			0012FF74
arraySi ze		0012FF81	numbers[1]		0012FF75
	4	0012FF81 0012FF82			0012FF76
		0012FF82 0012FF83			0012FF77
		00127763			0012FF78
			numb on a [9]		0012FF79
			numbers[2]		0012FF7A
const int arraySi	ze{ 4	};			0012FF7B
int numbers[arra	•				0012FF7C
<pre>for(int i{ 0 }; i < arraySize; ++i) numbers[i] = 5 * i;</pre>					0012FF7D
			numbers[3]		0012FF7E
					0012FF7F

i		0012FF6C	noumb a rea [O]	0	0012FF70
	1	0012FF6D			0012FF71
	1	0012FF6E	numbers[0]	U	0012FF72
		0012FF6F			0012FF73
		0012FF80			0012FF74
	4	0012FF80 0012FF81	numbers[1]	5	0012FF75
arraySi ze		0012FF81 0012FF82			0012FF76
					0012FF77
		0012FF83			0012FF78
			numb and [9]		0012FF79
			numbers[2]		0012FF7A
const int arraySi	ze{ 4	};			0012FF7B
int numbers[arra	•				0012FF7C
<pre>for(int i{ 0 }; numbers[i] -</pre>		ŭ			0012FF7D
<pre>numbers[i] = 5 * i;</pre>			numbers[3]		0012FF7E
					0012FF7F

i		0012FF6C	novembro no a [O]	0	0012FF70
	2	0012FF6D			0012FF71
	٤	0012FF6E	numbers[0]	U	0012FF72
		0012FF6F			0012FF73
		0012FF80			0012FF74
		0012FF81	numbers[1]	5	0012FF75
arraySi ze	4	0012FF81 0012FF82			0012FF76
		0012FF82 0012FF83			0012FF77
	00127783				0012FF78
			numbona[9]		0012FF79
			numbers[2]		0012FF7A
<pre>const int arraySi</pre>	ze{ 4	} ;			0012FF7B
int numbers[arra	•				0012FF7C
<pre>for(int i { 0 }; i < arraySize; ++i) numbers[i] = 5 * i;</pre>			numbana[2]		0012FF7D
			numbers[3]		0012FF7E
					0012FF7F

i		0012FF6C	numb on a [0]	0	0012FF70
	2	0012FF6D			0012FF71
	۵	0012FF6E	numbers[0]	U	0012FF72
		0012FF6F			0012FF73
		0012FF80			0012FF74
		0012FF81	numbers[1]	5	0012FF75
arraySi ze	4	0012FF81 0012FF82			0012FF76
		0012FF82 0012FF83			0012FF77
	00121183				0012FF78
			numbona[9]	10	0012FF79
			numbers[2]	10	0012FF7A
const int arraySi	ze{ 4	} ;			0012FF7B
int numbers[arra	•				0012FF7C
<pre>for(int i{ 0 }; numbers[i] -</pre>		ŭ			0012FF7D
<pre>numbers[i] = 5 * i;</pre>			numbers[3]		0012FF7E
					0012FF7F

		_			_
		0012FF6C			0012FF70
i	0	0012FF6D			0012FF71
	3	0012FF6E	numbers[0]	0	0012FF72
		0012FF6F			0012FF73
					0012FF74
arraySi ze	4	0012FF80	numbers[1]	5	0012FF75
		0012FF81			0012FF76
		0012FF82			0012FF77
	0012FF83				0012FF78
			1 [0]	4.0	0012FF79
			numbers[2]	10	0012FF7A
const int arraySi	ze{ 4	};			0012FF7B
<pre>int numbers[arra</pre>	ySi ze];			0012FF7C
<pre>for(int i{ 0 }; i < arraySize; ++i) numbers[i] = 5 * i;</pre>					0012FF7D
			numbers[3]		0012FF7E
					0012FF7F

i		0012FF6C	mumb o ma [O]	0	0012FF70
	3	0012FF6D			0012FF71
	3	0012FF6E	numbers[0]	U	0012FF72
		0012FF6F			0012FF73
		0012FF80			0012FF74
		0012FF81	numbers[1]	5	0012FF75
arraySi ze	4	0012FF81 0012FF82			0012FF76
		0012FF83			0012FF77
		00121103			0012FF78
			numbers[2]	10	0012FF79
			number S[2]		0012FF7A
const int arraySi	ze{ 4	} ;			0012FF7B
int numbers[arra	O				0012FF7C
<pre>for(int i{ 0 }; i < arraySize; ++i) numbers[i] = 5 * i;</pre>			numbers[3]	15	0012FF7D
			numers[3]	13	0012FF7E
					0012FF7F

i		0012FF6C	numb o n a [O]	0	0012FF70
	4	0012FF6D			0012FF71
	4	0012FF6E	numbers[0]	U	0012FF72
		0012FF6F			0012FF73
		0012FF80			0012FF74
		0012FF81	numbers[1]	5	0012FF75
arraySi ze	4	0012FF81 0012FF82			0012FF76
		0012FF82 0012FF83			0012FF77
		0012FF63			0012FF78
			numb and [9]	10	0012FF79
			numbers[2]	10	0012FF7A
const int arraySi	ze{ 4	} ;			0012FF7B
<pre>int numbers[arra</pre>	•				0012FF7C
<pre>for(int i{ 0 }; i < arraySize; ++i) numbers[i] = 5 * i;</pre>				1.5	0012FF7D
			numbers[3]	15	0012FF7E
					0012FF7F

Index	Val ue
0	0
1	5
2	10
3	15

```
int sum{ 0 };
sum += 1;
sum += 2;
sum += 3;
0012FF7C
0012FF7D
0012FF7E
0012FF7F
```

```
int sum{ 0 };
sum += 1;
sum += 2;
sum += 3;
0012FF7C
0012FF7D
0012FF7E
0012FF7F
```

```
int sum{ 0 };
sum += 1;
sum += 2;
sum += 3;
0012FF7C
0012FF7D
0012FF7E
0012FF7F
```

```
int sum{ 0 };
sum += 1;
sum += 2;
sum += 3;
0012FF7C
0012FF7D
0012FF7E
0012FF7F
```

```
int sum{ 0 };
sum += 1;
sum += 2;
sum += 3;
0012FF7C
0012FF7D
0012FF7E
0012FF7F
```

```
int sum{ 0 };
for(
   sum += i;
                                       0012FF78
                                       0012FF79
                                       0012FF7A
                                       0012FF7B
                                       0012FF7C
int sum{ 0 };
sum += 1;
                                       0012FF7D
                            sum
sum += 2;
                                       0012FF7E
sum += 3;
                                       0012FF7F
```

```
int sum{ 0 };
for(
   sum += i;
                                       0012FF78
                                       0012FF79
                                       0012FF7A
                                       0012FF7B
                                       0012FF7C
int sum{ 0 };
sum += 1;
                                       0012FF7D
                            sum
sum += 2;
                                       0012FF7E
sum += 3;
                                       0012FF7F
```

```
int sum{ 0 };
for(
   sum += i;
                                       0012FF78
                                       0012FF79
                                       0012FF7A
                                       0012FF7B
                                       0012FF7C
int sum{ 0 };
sum += 1;
                                       0012FF7D
                            sum
sum += 2;
                                       0012FF7E
sum += 3;
                                       0012FF7F
```

```
int sum{ 0 };
for(
   sum += i;
                                       0012FF78
                                       0012FF79
                                       0012FF7A
                                       0012FF7B
                                       0012FF7C
int sum{ 0 };
sum += 1;
                                       0012FF7D
                            sum
sum += 2;
                                       0012FF7E
sum += 3;
                                       0012FF7F
```

```
int sum{ 0 };
for(
   sum += i;
                                       0012FF78
                                       0012FF79
                                       0012FF7A
                                       0012FF7B
                                       0012FF7C
int sum{ 0 };
sum += 1;
                                       0012FF7D
                            sum
sum += 2;
                                       0012FF7E
sum += 3;
                                       0012FF7F
```

```
int sum{ 0 };
for(
   sum += i;
                                       0012FF78
                                       0012FF79
                                       0012FF7A
                                       0012FF7B
                                       0012FF7C
int sum{ 0 };
sum += 1;
                                       0012FF7D
                            sum
sum += 2;
                                       0012FF7E
sum += 3;
                                       0012FF7F
```

```
int sum{ 0 };
for(
   sum += i;
                                       0012FF78
                                       0012FF79
                                       0012FF7A
                                       0012FF7B
                                       0012FF7C
int sum{ 0 };
sum += 1;
                                       0012FF7D
                            sum
sum += 2;
                                       0012FF7E
sum += 3;
                                       0012FF7F
```

```
int sum{ 0 };
for(
   sum += i;
                                       0012FF78
                                       0012FF79
                                       0012FF7A
                                       0012FF7B
                                       0012FF7C
int sum{ 0 };
sum += 1;
                                       0012FF7D
                            sum
sum += 2;
                                       0012FF7E
sum += 3;
                                       0012FF7F
```

```
int sum{ 0 };
for(
   sum += i;
                                       0012FF78
                                       0012FF79
                                       0012FF7A
                                       0012FF7B
                                       0012FF7C
int sum{ 0 };
sum += 1;
                                       0012FF7D
                            sum
sum += 2;
                                       0012FF7E
sum += 3;
                                       0012FF7F
```

```
int sum{0};
for( int i{ 1 };     ;
   sum += i;
                                     0012FF78
                                     0012FF79
                                     0012FF7A
                                     0012FF7B
                                     0012FF7C
int sum{ 0 };
sum += 1;
                                     0012FF7D
                           sum
sum += 2;
                                     0012FF7E
sum += 3;
                                     0012FF7F
```

```
int sum{0};
sum += i;
                               0012FF78
                               0012FF79
                               0012FF7A
                               0012FF7B
                               0012FF7C
int sum{ 0 };
sum += 1;
                               0012FF7D
                      sum
sum += 2;
                               0012FF7E
sum += 3;
                               0012FF7F
```

```
int sum\{0\};
for( int i{ 1 }; i <= 3; ++i )</pre>
   sum += i;
                                        0012FF78
                                        0012FF79
                                        0012FF7A
                                        0012FF7B
                                        0012FF7C
int sum{ 0 };
sum += 1;
                                        0012FF7D
                             sum
sum += 2;
                                        0012FF7E
sum += 3;
                                        0012FF7F
```

```
int sum\{0\};
for( int i{ 1 }; i <= 3; ++i )</pre>
   sum += i;
                                        0012FF78
                                        0012FF79
                                        0012FF7A
                                        0012FF7B
                                        0012FF7C
int sum{ 0 };
sum += 1;
                                        0012FF7D
                             sum
sum += 2;
                                        0012FF7E
sum += 3;
                                        0012FF7F
```

```
int sum\{0\};
for( int i{ 1 }; i <= 3; ++i )</pre>
   sum += i;
                                        0012FF78
                                        0012FF79
                                        0012FF7A
                                        0012FF7B
                                        0012FF7C
int sum{ 0 };
sum += 1;
                                        0012FF7D
                             sum
sum += 2;
                                        0012FF7E
```

sum += 3;

```
int sum\{0\};
for( int i{ 1 }; i <= 3; ++i )</pre>
   sum += i;
                                        0012FF78
                                        0012FF79
                                        0012FF7A
                                        0012FF7B
                                        0012FF7C
int sum{ 0 };
sum += 1;
                                        0012FF7D
                             sum
sum += 2;
                                        0012FF7E
sum += 3;
```

```
int sum\{0\};
for( int i{ 1 }; i <= 3; ++i )</pre>
   sum += i;
                                        0012FF78
                                        0012FF79
                                        0012FF7A
                                        0012FF7B
                                        0012FF7C
int sum{ 0 };
sum += 1;
                                        0012FF7D
                             sum
sum += 2;
                                        0012FF7E
sum += 3;
```

```
int sum\{0\};
for( int i{ 1 }; i <= 3; ++i )</pre>
   sum += i;
                                        0012FF78
                                        0012FF79
                                        0012FF7A
                                        0012FF7B
                                        0012FF7C
int sum{ 0 };
sum += 1;
                                        0012FF7D
                             sum
sum += 2;
                                        0012FF7E
sum += 3;
```

```
int sum\{0\};
for( int i{ 1 }; i <= 3; ++i )</pre>
   sum += i;
                                        0012FF78
                                        0012FF79
                                        0012FF7A
                                        0012FF7B
                                        0012FF7C
int sum{ 0 };
sum += 1;
                                        0012FF7D
                             sum
sum += 2;
                                        0012FF7E
sum += 3;
```

```
int sum\{0\};
for( int i{ 1 }; i <= 3; ++i )</pre>
   sum += i;
                                        0012FF78
                                        0012FF79
                                        0012FF7A
                                        0012FF7B
                                        0012FF7C
int sum{ 0 };
sum += 1;
                                        0012FF7D
                             sum
sum += 2;
                                        0012FF7E
sum += 3;
```

0012FF7F

```
int sum\{0\};
for( int i{ 1 }; i <= 3; ++i )</pre>
   sum += i;
                                        0012FF78
                                        0012FF79
                                        0012FF7A
                                        0012FF7B
                                        0012FF7C
int sum{ 0 };
sum += 1;
                                        0012FF7D
                             sum
sum += 2;
                                        0012FF7E
sum += 3;
```

0012FF7F

```
#include <iostream>
using namespace std;

int main()
{
   int sum{ 0 };
   for( int i{ 1 }; i <= 3; ++i )
       sum += i;

   cout << "Sum = " << sum << endl;
}</pre>
```

```
#include <iostream>
using namespace std;

int main()
{
   const int arraySize{ 4 };
   int numbers[ arraySize ] = { 87, 68, 94, 100 };
   int sum{ 0 };

for( int i{ 0 }; i < arraySize; ++i )
      sum += numbers[ i ];

cout << "Sum of array elements: " << sum << endl;
}</pre>
```

Sum of array elements: 349

				ī
		0012FF68		0012FF70
		0012FF69	numb on a [O]	0012FF71
i		0012FF6A	numbers[0]	0012FF72
		0012FF6B		0012FF73
		0012FF6C		0012FF74
Cum		0012FF6D	numbona[1]	0012FF75
sum		0012FF6E	numbers[1]	0012FF76
		0012FF6F		0012FF77
				0012FF78
			numbers[2]	0012FF79
const int onnovi;	· (number s[2]	0012FF7A
<pre>const int arraySize int numbers[arrayS</pre>				0012FF7B
<pre>int sum{ 0 };</pre>	•	, , , , , , ,		0012FF7C
<pre>for(int i{ 0 }; i</pre>	numbona[9]	0012FF7D		
<pre>sum += numbers[i];</pre>			numbers[3]	0012FF7E
				0012FF7F

		0012FF68			0012FF70
i		0012FF69		~	0012FF71
		0012FF6A	numbers[0]	7	0012FF72
		0012FF6B			0012FF73
		0012FF6C			0012FF74
		0012FF6D	1 [4]	8	0012FF75
sum		0012FF6E	numbers[1]		0012FF76
		0012FF6F			0012FF77
					0012FF78
					0012FF79
	- (_	numbers[2]	4	0012FF7A
<pre>const int arraySize int numbers[arraySize</pre>					0012FF7B
<pre>int sum{ 0 };</pre>	or ze j	_ (', ', ', ', ', ', ', ', ', ', ', ', ',			0012FF7C
<pre>for(int i{ 0 }; i</pre>	aySi ze; ++i)	1 [0]		0012FF7D	
<pre>sum += numbers[i];</pre>			numbers[3]	6	0012FF7E
					0012FF7F
					4

		0012FF68			0012FF70
i		0012FF69		~	0012FF71
		0012FF6A	numbers[0]	7	0012FF72
		0012FF6B			0012FF73
		0012FF6C		8	0012FF74
	0	0012FF6D			0012FF75
sum	0	0012FF6E	numbers[1]		0012FF76
		0012FF6F			0012FF77
		•			0012FF78
					0012FF79
	.		numbers[2]	4	0012FF7A
const int arraySize	_				0012FF7B
int numbers[arrays	size j	= { /, 8, 4, 6 };			0012FF7C
<pre>int sum{ 0 };</pre>					
for(int i{ 0 }; i		numbers[3]	6	0012FF7D	
<pre>sum += numbers[i];</pre>			Tulliber 5[3]		0012FF7E
					0012FF7F

		_			_
٠		0012FF68			0012FF70
	0	0012FF69		~	0012FF71
i	0	0012FF6A	numbers[0]	7	0012FF72
		0012FF6B			0012FF73
		0012FF6C			0012FF74
		0012FF6D		8	0012FF75
sum	0	0012FF6E	numbers[1]	ð	0012FF76
		0012FF6F			0012FF77
			0012FF78		
			1 [0]		0012FF79
const int amousting	o (numbers[2]	4	0012FF7A
<pre>const int arraySize int numbers[arraySize</pre>					0012FF7B
<pre>int sum{ 0 };</pre>	,	(', ', ', ', ', ', ', ', ', ', ', ', ',			0012FF7C
<pre>for(int i{ 0 }; i</pre>		0	0012FF7D		
sum += numbers[numbers[3]	6	0012FF7E		
					0012FF7F

		_			_
<u>.</u>		0012FF68			0012FF70
	0	0012FF69		7	0012FF71
i	0	0012FF6A	numbers[0]		0012FF72
		0012FF6B			0012FF73
		0012FF6C			0012FF74
	~	0012FF6D		0	0012FF75
sum	7	0012FF6E	numbers[1]	8	0012FF76
		0012FF6F			0012FF77
			0012FF78		
			1 [0]		0012FF79
const int amoustic	o (numbers[2]	4	0012FF7A
<pre>const int arraySize int numbers[arraySize</pre>					0012FF7B
<pre>int sum{ 0 };</pre>		(', ', ', ', ', ', ', ', ', ', ', ', ',			0012FF7C
<pre>for(int i{ 0 }; i</pre>		C	0012FF7D		
<pre>sum += numbers[i];</pre>			numbers[3]	6	0012FF7E
					0012FF7F

		_			_
		0012FF68			0012FF70
<u>.</u>	,	0012FF69		7	0012FF71
i	1	0012FF6A	numbers[0]	/	0012FF72
		0012FF6B			0012FF73
		0012FF6C			0012FF74
	~	0012FF6D		0	0012FF75
sum	7	0012FF6E	numbers[1]	8	0012FF76
		0012FF6F			0012FF77
			0012FF78		
			1 [0]		0012FF79
const int amoustic	o (numbers[2]	4	0012FF7A
<pre>const int arraySize int numbers[arraySize</pre>					0012FF7B
<pre>int sum{ 0 };</pre>	,	(', ', ', ', ', ', ', ', ', ', ', ', ',			0012FF7C
<pre>for(int i{ 0 }; i</pre>		C	0012FF7D		
<pre>sum += numbers[i];</pre>			numbers[3]	6	0012FF7E
					0012FF7F

		_			_
i		0012FF68			0012FF70
	1	0012FF69		7	0012FF71
1	1	0012FF6A	numbers[0]	/	0012FF72
		0012FF6B			0012FF73
		0012FF6C			0012FF74
	1 ~	0012FF6D	1 [4]	0	0012FF75
sum		0012FF6E	numbers[1]	8	0012FF76
		0012FF6F			0012FF77
			0012FF78		
					0012FF79
	- (_	numbers[2]	4	0012FF7A
<pre>const int arraySize int numbers[arraySize</pre>	_				0012FF7B
<pre>int sum{ 0 };</pre>	31 Ze]	- (', ', ', ', ', ', ', ', ', ', ', ', ',			0012FF7C
<pre>for(int i{ 0 }; i</pre>	1 [0]		0012FF7D		
<pre>sum += numbers[i];</pre>			numbers[3]	6	0012FF7E
					0012FF7F
					-

	_	_			_
٠		0012FF68			0012FF70
	o	0012FF69		7	0012FF71
i	2	0012FF6A	numbers[0]	/	0012FF72
		0012FF6B			0012FF73
		0012FF6C			0012FF74
	1.5	0012FF6D		0	0012FF75
sum	15	0012FF6E	numbers[1]	8	0012FF76
		0012FF6F			0012FF77
			1 [0]		0012FF79
const int amoust s	a (numbers[2]	4	0012FF7A
<pre>const int arraySize int numbers[arraySize</pre>	_				0012FF7B
<pre>int sum{ 0 };</pre>	,	(', ', ', ', ', ', ', ', ', ', ', ', ',			0012FF7C
<pre>for(int i{ 0 }; i</pre>		0	0012FF7D		
<pre>sum += numbers[i];</pre>			numbers[3]	6	0012FF7E
					0012FF7F
					-

	_	_			_
•		0012FF68			0012FF70
	o	0012FF69		7	0012FF71
i	2	0012FF6A	numbers[0]	/	0012FF72
		0012FF6B			0012FF73
		0012FF6C			0012FF74
	10	0012FF6D		0	0012FF75
sum	19	0012FF6E	numbers[1]	8	0012FF76
		0012FF6F			0012FF77
			0012FF78		
			1 [0]		0012FF79
const int amoust s	a (numbers[2]	4	0012FF7A
<pre>const int arraySize int numbers[arraySize</pre>	_				0012FF7B
<pre>int sum{ 0 };</pre>	,	(', ', ', ', ', ', ', ', ', ', ', ', ',			0012FF7C
<pre>for(int i{ 0 }; i</pre>		C	0012FF7D		
<pre>sum += numbers[i];</pre>			numbers[3]	6	0012FF7E
					0012FF7F
					_

		_			_
•		0012FF68			0012FF70
	9	0012FF69	1 [0]	_	0012FF71
i	3	0012FF6A	numbers[0]	7	0012FF72
		0012FF6B			0012FF73
		0012FF6C			0012FF74
	10	0012FF6D	l [1]	0	0012FF75
sum	19	0012FF6E	numbers[1]	8	0012FF76
		0012FF6F			0012FF77
			0012FF78		
			1 [0]		0012FF79
const int amousting	o (numbers[2]	4	0012FF7A
<pre>const int arraySize int numbers[arraySize</pre>					0012FF7B
<pre>int sum{ 0 };</pre>	,	(', ', ', ', ', ', ', ', ', ', ', ', ',			0012FF7C
<pre>for(int i{ 0 }; i</pre>			0012FF7D		
<pre>sum += numbers[i];</pre>			numbers[3]	6	0012FF7E
					0012FF7F

i 3 0012FF68 0012FF69 0012FF70 0012FF71 0012FF72 0012FF72 0012FF6B 0012FF6B 0012FF6D 0012FF6E 0012FF6E 0012FF6F 0012FF75 0012FF75 0012FF75 0012FF75 0012FF77 0012FF78 1nt numbers[arraySize] = { 7, 8, 4, 6 }; int numbers[arraySize] = { 7, 8, 4, 6 }; int sum{ 0 }; for(int i{ 0 }; i < arraySize; ++i) sum += numbers[i]; numbers[3] 6 0012FF75 0012FF7		_	_			_
i 3	<u>.</u>		0012FF68			0012FF70
sum 0012FF6A 0012FF6B 0012FF6C 0012FF6D 0012FF6E 0012FF6F 0012FF73 0012FF75 0012FF75 0012FF76 0012FF76 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF7B 1 0012FF7B 1 0012FF7B 1 0012FF7B 0012FF7B 0012FF7B 0012FF7B		a		~	0012FF71	
sum 25 0012FF6C 0012FF6D 0012FF6E 0012FF6E 0012FF6F numbers[1] 8 0012FF75 0012FF76 0012FF76 0012FF77 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF7B 0012FF7B 0012FF7B 0012FF7B 0012FF7B 0012FF7C 0012FF7C 0012FF7C 0012FF7C 0012FF7C 0012FF7C 0012FF7D 0012FF7D 0012FF7E	1	3	0012FF6A	numbers[v]	/	0012FF72
sum 25 0012FF6D 0012FF6E 0012FF6E 0012FF75 numbers[1] 8 0012FF75 0012FF76 0012FF76 0012FF77 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF7B 0012FF7B 0012FF7B 0012FF7B 0012FF7B 0012FF7B 0012FF7C 0012FF7B 0012FF7C 0012FF7B 001			0012FF6B			0012FF73
<pre>sum 25</pre>			0012FF6C			0012FF74
0012FF6E 0012FF6F 0012FF6F 0012FF77 0012FF78 0012FF78 0012FF78 0012FF79 0012FF79 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF78 0012FF7B int sum{ 0 }; int sum{ 0 }; for(int i{ 0 }; i < arraySize; ++i) sum += numbers[i]; 0012FF76 0012FF78 0012FF7B 0012FF7B		0.5	0012FF6D		0	0012FF75
<pre>const int arraySize{ 4 }; int numbers[arraySize] = { 7, 8, 4, 6 }; int sum{ 0 }; for(int i{ 0 }; i < arraySize; ++i) sum += numbers[i];</pre>	Sum	25	0012FF6E	numbers[1]	8	0012FF76
<pre>numbers[2] 4 const int arraySize{ 4 }; int numbers[arraySize] = { 7, 8, 4, 6 }; int sum{ 0 }; for(int i{ 0 }; i < arraySize; ++i) sum += numbers[i]; numbers[3] 6 0012FF79 0012FF7B 0012FF7D 0012FF7D 0012FF7D</pre>			0012FF6F			0012FF77
<pre>const int arraySize{ 4 }; int numbers[arraySize] = { 7, 8, 4, 6 }; int sum{ 0 }; for(int i{ 0 }; i < arraySize; ++i) sum += numbers[i]; numbers[3]</pre>				0012FF78		
<pre>const int arraySize{ 4 }; int numbers[arraySize] = { 7, 8, 4, 6 }; int sum{ 0 }; for(int i{ 0 }; i < arraySize; ++i) sum += numbers[i];</pre>				1 [0]		0012FF79
<pre>int numbers[arraySize] = { 7, 8, 4, 6 }; int sum{ 0 }; for(int i{ 0 }; i < arraySize; ++i) sum += numbers[i];</pre>	const int annoySize	o (numbers[2]	4	0012FF7A
<pre>int sum{ 0 }; for(int i{ 0 }; i < arraySize; ++i) sum += numbers[i]; numbers[3] 6 0012FF7C 0012FF7D 0012FF7D</pre>	v					0012FF7B
<pre>sum += numbers[i]; numbers[3] 6 0012FF7E</pre>	v	,	(', ', ', ', ', ', ', ', ', ', ', ', ',			0012FF7C
Sum += numbers[1]; 0012FF7E	<pre>for(int i{ 0 }; i</pre>		C	0012FF7D		
0012FF7F	<pre>sum += numbers[i];</pre>			numbers[3]	O	0012FF7E
						0012FF7F

					_
•		0012FF68			0012FF70
	4	0012FF69		7	0012FF71
i	4	0012FF6A	numbers[0]	/	0012FF72
		0012FF6B			0012FF73
		0012FF6C			0012FF74
	0.5	0012FF6D	1 [4]	0	0012FF75
sum	25	0012FF6E	numbers[1]	8	0012FF76
		0012FF6F			0012FF77
			0012FF78		
				,	0012FF79
	- (numbers[2]	4	0012FF7A
<pre>const int arraySize int numbers[arraySize</pre>	_				0012FF7B
<pre>int sum{ 0 };</pre>	31 Ze]	- (', ', ', ', ', ', ', ', ', ', ', ', ',			0012FF7C
<pre>for(int i{ 0 }; i</pre>	1 [0]		0012FF7D		
<pre>sum += numbers[i];</pre>			numbers[3]	6	0012FF7E
					0012FF7F
					-

Range-based for loop

```
#include <iostream>
using namespace std;

int main()
{
   const int arraySize = 4;
   int numbers[ arraySize ] = { 87, 68, 94, 100 };
   int sum{ 0 };

for( int number: numbers )
     sum += number;

cout << "Sum of array elements: " << sum << endl;
}</pre>
```

Sum of array elements: 349

Counter-Controlled Repetition

- Definite repetition
 - Number of repetitions known
- Example

A class of ten students took a quiz. The grades (integers in the range 0 to 100) for this quiz are available to you. Calculate and display the total of all student grades and the class average on the quiz.

```
0012FEE8
int grade;
                                                      0012FEE9
int sum{ 0 };
                                      average
                                                      0012FEEA
cout << "Enter grade: ";</pre>
                                                      0012FEEB
cin >> grade;
sum += grade;
                                                      0012FEEC
                                                      0012FEED
cout << "Enter grade: ";</pre>
                                           sum
cin >> grade;
                                                      0012FEEE
sum += grade;
                                                      0012FEEF
cout << "Enter grade: ";</pre>
                                                      0012FEF4
cin >> grade;
                                                      0012FEF5
sum += grade;
                                        grade
                                                      0012FEF6
int average{ sum / 3 };
                                                      0012FEF7
```

```
0012FEE8
int grade;
                                                      0012FEE9
int sum{ 0 };
                                      average
                                                      0012FEEA
cout << "Enter grade: ";</pre>
                                                      0012FEEB
cin >> grade;
sum += grade;
                                                      0012FEEC
                                                      0012FEED
cout << "Enter grade: ";</pre>
                                                 0
                                           sum
cin >> grade;
                                                      0012FEEE
sum += grade;
                                                      0012FEEF
cout << "Enter grade: ";</pre>
                                                      0012FEF4
cin >> grade;
                                                      0012FEF5
sum += grade;
                                        grade
                                                      0012FEF6
int average{ sum / 3 };
                                                      0012FEF7
```

```
0012FEE8
int grade;
                                                      0012FEE9
int sum{ 0 };
                                      average
                                                      0012FEEA
cout << "Enter grade: ";</pre>
                                                      0012FEEB
cin >> grade;
sum += grade;
                                                      0012FEEC
                                                      0012FEED
cout << "Enter grade: ";</pre>
                                                 0
                                           sum
cin >> grade;
                                                      0012FEEE
sum += grade;
                                                      0012FEEF
cout << "Enter grade: ";</pre>
                                                      0012FEF4
cin >> grade;
                                                      0012FEF5
sum += grade;
                                        grade
                                                 70
                                                      0012FEF6
int average{ sum / 3 };
                                                      0012FEF7
```

```
0012FEE8
int grade;
                                                      0012FEE9
int sum{ 0 };
                                      average
                                                      0012FEEA
cout << "Enter grade: ";</pre>
                                                      0012FEEB
cin >> grade;
sum += grade;
                                                      0012FEEC
                                                      0012FEED
cout << "Enter grade: ";</pre>
                                                 70
                                           sum
cin >> grade;
                                                      0012FEEE
sum += grade;
                                                      0012FEEF
cout << "Enter grade: ";</pre>
                                                      0012FEF4
cin >> grade;
                                                      0012FEF5
sum += grade;
                                        grade
                                                 70
                                                      0012FEF6
int average{ sum / 3 };
                                                      0012FEF7
```

```
0012FEE8
int grade;
                                                      0012FEE9
int sum{ 0 };
                                      average
                                                      0012FEEA
cout << "Enter grade: ";</pre>
                                                      0012FEEB
cin >> grade;
sum += grade;
                                                      0012FEEC
                                                      0012FEED
cout << "Enter grade: ";</pre>
                                                 70
                                           sum
cin >> grade;
                                                      0012FEEE
sum += grade;
                                                      0012FEEF
cout << "Enter grade: ";</pre>
                                                      0012FEF4
cin >> grade;
                                                      0012FEF5
sum += grade;
                                        grade
                                                 80
                                                      0012FEF6
int average{ sum / 3 };
                                                      0012FEF7
```

```
0012FEE8
int grade;
                                                      0012FEE9
int sum{ 0 };
                                      average
                                                      0012FEEA
cout << "Enter grade: ";</pre>
                                                      0012FEEB
cin >> grade;
sum += grade;
                                                      0012FEEC
                                                      0012FEED
cout << "Enter grade: ";</pre>
                                                150
                                           sum
cin >> grade;
                                                      0012FEEE
sum += grade;
                                                      0012FEEF
cout << "Enter grade: ";</pre>
                                                      0012FEF4
cin >> grade;
                                                      0012FEF5
sum += grade;
                                        grade
                                                 80
                                                      0012FEF6
int average{ sum / 3 };
                                                      0012FEF7
```

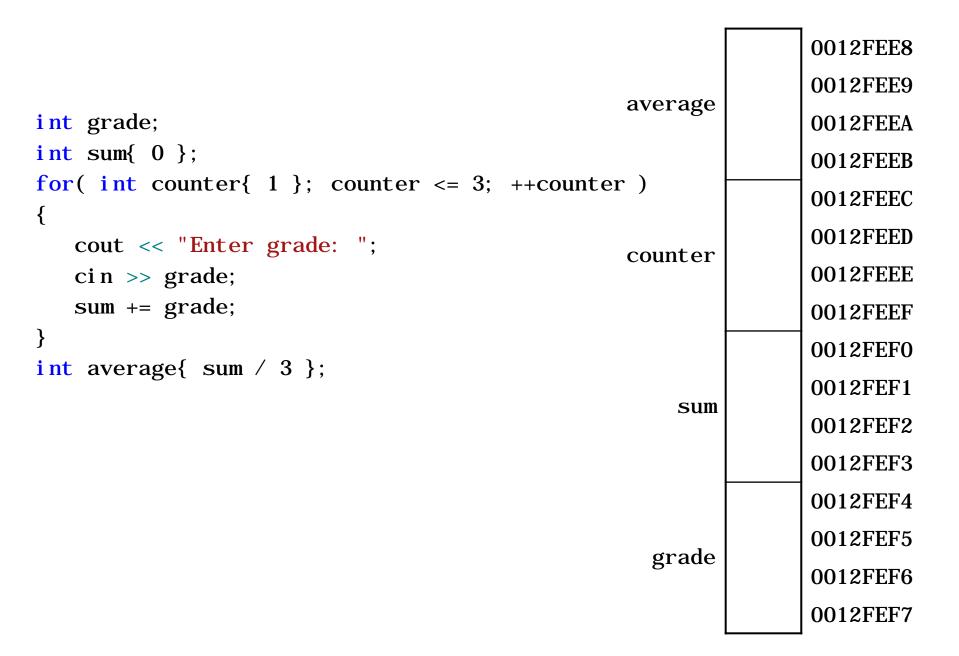
```
0012FEE8
int grade;
                                                      0012FEE9
int sum{ 0 };
                                      average
                                                      0012FEEA
cout << "Enter grade: ";</pre>
                                                      0012FEEB
cin >> grade;
sum += grade;
                                                      0012FEEC
                                                      0012FEED
cout << "Enter grade: ";</pre>
                                                150
                                           sum
cin >> grade;
                                                      0012FEEE
sum += grade;
                                                      0012FEEF
cout << "Enter grade: ";</pre>
                                                      0012FEF4
cin >> grade;
                                                      0012FEF5
sum += grade;
                                        grade
                                                 90
                                                      0012FEF6
int average{ sum / 3 };
                                                      0012FEF7
```

```
0012FEE8
int grade;
                                                      0012FEE9
int sum{ 0 };
                                      average
                                                      0012FEEA
cout << "Enter grade: ";</pre>
                                                      0012FEEB
cin >> grade;
sum += grade;
                                                      0012FEEC
                                                      0012FEED
cout << "Enter grade: ";</pre>
                                                240
                                           sum
cin >> grade;
                                                      0012FEEE
sum += grade;
                                                      0012FEEF
cout << "Enter grade: ";</pre>
                                                      0012FEF4
cin >> grade;
                                                      0012FEF5
sum += grade;
                                        grade
                                                 90
                                                      0012FEF6
int average{ sum / 3 };
                                                      0012FEF7
```

```
0012FEE8
int grade;
                                                      0012FEE9
int sum{ 0 };
                                                 80
                                      average
                                                      0012FEEA
cout << "Enter grade: ";</pre>
                                                      0012FEEB
cin >> grade;
sum += grade;
                                                      0012FEEC
                                                      0012FEED
cout << "Enter grade: ";</pre>
                                                240
                                           sum
cin >> grade;
                                                      0012FEEE
sum += grade;
                                                      0012FEEF
cout << "Enter grade: ";</pre>
                                                      0012FEF4
cin >> grade;
                                                      0012FEF5
sum += grade;
                                        grade
                                                 90
                                                      0012FEF6
int average{ sum / 3 };
                                                      0012FEF7
```

```
int grade;
int sum{ 0 };
for(
   cout << "Enter grade: ";</pre>
   cin >> grade;
                                          int grade;
   sum += grade;
                                          int sum{ 0 };
}
int average{ sum / 3 };
                                          cout << "Enter grade: ";</pre>
                                          cin >> grade;
                                          sum += grade;
                                          cout << "Enter grade: ";</pre>
                                          cin >> grade;
                                          sum += grade;
                                          cout << "Enter grade: ";</pre>
                                          cin >> grade;
                                          sum += grade;
                                          int average{ sum / 3 };
```

```
int grade;
int sum{ 0 };
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
   cout << "Enter grade: ";</pre>
   cin >> grade;
                                          int grade;
   sum += grade;
                                          int sum{ 0 };
}
int average{ sum / 3 };
                                          cout << "Enter grade: ";</pre>
                                          cin >> grade;
                                          sum += grade;
                                          cout << "Enter grade: ";</pre>
                                          cin >> grade;
                                          sum += grade;
                                          cout << "Enter grade: ";</pre>
                                          cin >> grade;
                                          sum += grade;
                                          int average{ sum / 3 };
```



			0012FEE8
			0012FEE9
int grade;	grade; average		0012FEEA
<pre>int sum{ 0 };</pre>	<pre>nt sum{ 0 };</pre>		0012FEEB
<pre>for(int counter{ 1 }; counter <= 3; ++counter)</pre>			0012FEEC
{			0012FEED
	unter		0012FEEE
cin >> grade; sum += grade;			
<pre>sum += grade, } int average{ sum / 3 };</pre>			0012FEEF
	a	0	0012FEF0
			0012FEF1
	sum		0012FEF2
			0012FEF3
			0012FEF4
grade	anada		0012FEF5
	graue		0012FEF6
			0012FEF7

int grade; int sum{ 0 }; for(int counter{ 1 }; counter <= 3; ++counter) { cout << "Enter grade: "; cin >> grade; sum += grade; } int average{ sum / 3 }; sum outstands out				0012FEE8
<pre>int grade; int sum{ 0 }; for(int counter{ 1 }; counter <= 3; ++counter) { cout << "Enter grade: "; cin >> grade; sum += grade; } int average{ sum / 3 }; sum ounter ounter oun</pre>				0012FEE9
for(int counter{ 1 }; counter <= 3; ++counter) { cout << "Enter grade: "; cin >> grade; sum += grade; } int average{ sum / 3 }; sum ounter ounter counter ounter o	int grade;			0012FEEA
{ cout << "Enter grade: "; cin >> grade; sum += grade; } int average{ sum / 3 }; sum counter 1	<pre>int sum{ 0 };</pre>			0012FEEB
cout << "Enter grade: "; cin >> grade; sum += grade; } int average{ sum / 3 }; sum 0 0012FEED 0012FEEE 0012FEFF 0012FEFF 0012FEF0 0012FEF1 0012FEF2 0012FEF3 0012FEF5 0012FEF5)		0012FEEC
cin >> grade; sum += grade; } int average{ sum / 3 }; sum 0 0012FEEE 0012FEF0 0012FEF0 0012FEF1 0012FEF2 0012FEF3 0012FEF5 0012FEF5	cout // "Entor grado: ":	a grado: ":	_	0012FEED
sum += grade; 0012FEFF int average{ sum / 3 }; 0012FEF0 sum 0 0012FEF1 0012FEF2 0012FEF2 0012FEF3 0012FEF4 0012FEF5 0012FEF5 0012FEF6 0012FEF6		counter	1	0012FEEE
int average{ sum / 3 }; sum 0 0012FEF0 0012FEF1 0012FEF2 0012FEF3 0012FEF5 0012FEF5				0012FEEF
sum 0 0012FEF1 0012FEF2 0012FEF3 0012FEF4 0012FEF5 0012FEF6			0	0012FEF0
0012FEF2 0012FEF3 0012FEF4 0012FEF5 0012FEF6				0012FEF1
grade		sum		0012FEF2
grade 0012FEF5 0012FEF6				0012FEF3
grade 0012FEF6				0012FEF4
0012FEF6	grade			0012FEF5
		grade		0012FEF6
				0012FEF7

int grade;	verage		0012FEE8 0012FEE9 0012FEEA
<pre>int sum{ 0 };</pre>	,		0012FEEB
	ounter	1	0012FEEC 0012FEED 0012FEEE
<pre>cin >> grade; sum += grade; } int average{ sum / 3 }; sum grade</pre>			0012FEEF
	sum	0	0012FEF0 0012FEF1 0012FEF2
			0012FEF3
			0012FEF4 0012FEF5
	grade	70	0012FEF3
		0012FEF7	

			0012FEE8
average		0012FEE9	
int grade;	crage		0012FEEA
<pre>int sum{ 0 };</pre>			0012FEEB
<pre>for(int counter{ 1 }; counter <= 3; ++counter)</pre>			0012FEEC
<pre>cout << "Enter grade: ";</pre>	counter	1	0012FEED
cin >> grade;	unter	1	0012FEEE
sum += grade;			0012FEEF
<pre>int average{ sum / 3 };</pre>	Gum	70	0012FEF0
			0012FEF1
	sum		0012FEF2
		0012FEF3	
		70	0012FEF4
grade	grado		0012FEF5
	70	0012FEF6	
		0012FEF7	

			0012FEE8
			0012FEE9
int grade;	se		0012FEEA
<pre>int sum{ 0 };</pre>			0012FEEB
<pre>for(int counter{ 1 }; counter <= 3; ++counter)</pre>	-		0012FEEC
<pre>{ cout << "Enter grade: "; count</pre>			0012FEED
cin >> grade;	er	2	0012FEEE
sum += grade;			0012FEEF
}		70	0012FEF0
<pre>int average{ sum / 3 };</pre>			0012FEF1
St	ım		0012FEF2
			0012FEF3
		70	0012FEF4
	اما		0012FEF5
grade	ie	70	0012FEF6
			0012FEF7

			0012FEE8
		0012FEE9	
int grade;	erage		0012FEEA
<pre>int sum{ 0 };</pre>			0012FEEB
<pre>for(int counter{ 1 }; counter <= 3; ++counter)</pre>			0012FEEC
{			0012FEED
	unter	2	
cin >> grade;			0012FEEE
sum += grade;			0012FEEF
<pre>int average{ sum / 3 };</pre>		70	0012FEF0
	Gum		0012FEF1
	sum		0012FEF2
			0012FEF3
	anada	80	0012FEF4
grade			0012FEF5
	ου	0012FEF6	
			0012FEF7

			0012FEE8
	arione de		0012FEE9
int grade;	ge		0012FEEA
<pre>int sum{ 0 };</pre>			0012FEEB
<pre>for(int counter{ 1 }; counter <= 3; ++counter) {</pre>			0012FEEC
cout // "Entor grado: ":	counter	2	0012FEED
cin >> grade;		2	0012FEEE
sum += grade;			0012FEEF
} int avamage (gym / 2).			0012FEF0
nt average{ sum / 3 };	150	0012FEF1	
S	sum	150	0012FEF2
			0012FEF3
			0012FEF4
grade	٩٥	90	0012FEF5
	ue	80	0012FEF6
			0012FEF7

<pre>int grade; int sum{ 0 }; for(int counter{ 1 }; counter <= 3; ++counter) { cout << "Enter grade: "; cin >> grade; } description of the counter of the counter</pre>				0012FEE8
<pre>int grade; int sum{ 0 }; for(int counter{ 1 }; counter <= 3; ++counter) { cout << "Enter grade: "; cin >> grade; definition of the counter of the counte</pre>				0012FEE9
<pre>for(int counter{ 1 }; counter <= 3; ++counter) { cout << "Enter grade: "; ci n >> grade; } counter <= 3; ++counter) 0012FEED 0012FEED 0012FEED 0012FEED 0012FEED 0012FEED</pre>	int grade;	average		0012FEEA
cout << "Enter grade: "; cin >> grade; counter 3 counter 3 0012FEEC 0012FEEC 0012FEEC 0012FEEC 0012FEEC				0012FEEB
cout << "Enter grade: "; cin >> grade; counter 3 0012FEED 0012FEED		r)		0012FEEC
cin >> grade; 0012FEEE			3	0012FEED
		counter		0012FEEE
sum += grade; 0012FEEF	sum += grade;			0012FEEF
	<pre>int average{ sum / 3 };</pre>			0012FEF0
0012FEF1			0012FEF1	
		sum	150	0012FEF2
0012FEF3			0012FEF3	
0012FEF4	grade			0012FEF4
0012FEF5		_		0012FEF5
grade 80 0012FEF6		80	0012FEF6	
0012FEF7			0012FEF7	

		0012FEE8
		0012FEE9
int grade; average		0012FEEA
<pre>int sum{ 0 };</pre>		0012FEEB
<pre>for(int counter{ 1 }; counter <= 3; ++counter)</pre>		0012FEEC
<pre>cout << "Enter grade: ";</pre>		0012FEED
cout << Enter grade. , counter cin >> grade;	3	0012FEEE
sum += grade;		0012FEEF
}		0012FEF0
nt average{ sum / 3 };	150	0012FEF1
sun	150	0012FEF2
		0012FEF3
		0012FEF4
grade	00	0012FEF5
	90	0012FEF6
		0012FEF7

			0012FEE8
			0012FEE9
int grade;	erage		0012FEEA
<pre>int sum{ 0 };</pre>			0012FEEB
<pre>for(int counter{ 1 }; counter <= 3; ++counter)</pre>			0012FEEC
{	counter	3	0012FEED
cout << "Enter grade: "; coucin >> grade;			0012FEEE
sum += grade;			0012FEEF
}			
<pre>int average{ sum / 3 };</pre>			0012FEF0
		240	0012FEF1
			0012FEF2
		0012FEF3	
grade			0012FEF4
	mado	90	0012FEF5
	30	0012FEF6	
		0012FEF7	

			0012FEE8
			0012FEE9
int grade;	erage		0012FEEA
<pre>int sum{ 0 };</pre>			0012FEEB
<pre>for(int counter{ 1 }; counter <= 3; ++counter)</pre>			0012FEEC
<pre>cout << "Enter grade: ";</pre>	counter	_	0012FEED
cin >> grade;		4	0012FEEE
sum += grade;			0012FEEF
}			0012FEF0
nt average{ sum / 3 };	940	0012FEF1	
	sum	240	0012FEF2
			0012FEF3
grade		90	0012FEF4
	mada		0012FEF5
	90	0012FEF6	
			0012FEF7

		0012FEE8
	00	0012FEE9
int grade; average	80	0012FEEA
<pre>int sum{ 0 };</pre>		0012FEEB
<pre>for(int counter{ 1 }; counter <= 3; ++counter)</pre>		0012FEEC
<pre>{ cout << "Enter grade: "; counter</pre>	4	0012FEED
cin >> grade; counter		0012FEEE
sum += grade;		0012FEEF
}		0012FEF0
nt average{ sum / 3 };	240	0012FEF1
sum		0012FEF2
		0012FEF3
grade		0012FEF4
		0012FEF5
	90	0012FEF6
		0012FEF7

```
#include <iostream>
using namespace std;
int main ()
{
   int grade[ 11 ];
   int sum{ 0 };
   for( int counter{ 1 }; counter <= 10; ++counter )</pre>
      cout << "Enter grade: ";</pre>
      cin >> grade[ counter ];
      sum += grade[ counter ];
   }
   int average{ sum / 3 }; // average of grades
   cout << "\nThe sum of all 3 grades is " << sum << endl;</pre>
   cout << "Class average is " << average << endl;</pre>
}
```

Enter grade: 98

Enter grade: 76

Enter grade: 71

Enter grade: 87

Enter grade: 83

Enter grade: 90

Enter grade: 57

Enter grade: 79

Enter grade: 82

Enter grade: 94

Class average is 81

```
int sum{ 0 };
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                          average
                                                          0012FF60
   sum += grade[ counter ];
                                         grade[0]
                                                          0012FF64
int average{ sum / 3 };
                                                          0012FF68
                                         grade[1]
                                         grade[2]
                                                          0012FF6C
                                         grade[3]
                                                          0012FF70
                                                          0012FF74
                                          counter
                                                          0012FF78
                                              sum
```

```
int sum{ 0 };
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                          average
                                                          0012FF60
   sum += grade[ counter ];
                                         grade[0]
                                                          0012FF64
int average{ sum / 3 };
                                                          0012FF68
                                         grade[1]
                                         grade[2]
                                                          0012FF6C
                                         grade[3]
                                                          0012FF70
                                                          0012FF74
                                          counter
                                                     1
                                                          0012FF78
                                                     0
                                              sum
```

```
int sum{ 0 };
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                          average
                                                          0012FF60
   sum += grade[ counter ];
                                         grade[0]
                                                          0012FF64
}
int average{ sum / 3 };
                                                          0012FF68
                                         grade[1]
                                                     70
                                         grade[2]
                                                          0012FF6C
                                         grade[3]
                                                          0012FF70
                                                          0012FF74
                                          counter
                                                     1
                                                          0012FF78
                                                     0
                                               sum
```

```
int sum{ 0 };
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                          average
                                                          0012FF60
   sum += grade[ counter ];
                                         grade[0]
                                                          0012FF64
}
int average{ sum / 3 };
                                                          0012FF68
                                         grade[1]
                                                     70
                                         grade[2]
                                                          0012FF6C
                                         grade[3]
                                                          0012FF70
                                                          0012FF74
                                          counter
                                                     1
                                                     70
                                                          0012FF78
                                               sum
```

```
int sum{ 0 };
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                          average
                                                          0012FF60
   sum += grade[ counter ];
                                         grade[0]
                                                          0012FF64
}
int average{ sum / 3 };
                                                          0012FF68
                                         grade[1]
                                                     70
                                                          0012FF6C
                                         grade[2]
                                         grade[3]
                                                          0012FF70
                                                          0012FF74
                                          counter
                                                     2
                                                     70
                                                          0012FF78
                                               sum
```

```
int sum{ 0 };
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                          average
                                                          0012FF60
   sum += grade[ counter ];
                                         grade[0]
                                                          0012FF64
}
int average{ sum / 3 };
                                         grade[1]
                                                     70
                                                          0012FF68
                                         grade[2]
                                                     80
                                                          0012FF6C
                                         grade[3]
                                                          0012FF70
                                                          0012FF74
                                          counter
                                                     2
                                                     70
                                                          0012FF78
                                               sum
```

```
int sum{ 0 };
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                          average
                                                          0012FF60
   sum += grade[ counter ];
                                         grade[0]
                                                          0012FF64
}
int average{ sum / 3 };
                                         grade[1]
                                                     70
                                                          0012FF68
                                         grade[2]
                                                     80
                                                          0012FF6C
                                         grade[3]
                                                          0012FF70
                                                          0012FF74
                                          counter
                                                     2
                                                    150
                                                          0012FF78
                                               sum
```

```
int sum{ 0 };
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                          average
                                                          0012FF60
   sum += grade[ counter ];
                                         grade[0]
                                                          0012FF64
}
int average{ sum / 3 };
                                         grade[1]
                                                     70
                                                          0012FF68
                                         grade[2]
                                                     80
                                                          0012FF6C
                                         grade[3]
                                                          0012FF70
                                                     3
                                                          0012FF74
                                          counter
                                                    150
                                                          0012FF78
                                               sum
```

```
int sum{ 0 };
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                          0012FF60
                                          average
   sum += grade[ counter ];
                                         grade[0]
                                                          0012FF64
}
int average{ sum / 3 };
                                         grade[1]
                                                     70
                                                          0012FF68
                                         grade[2]
                                                     80
                                                          0012FF6C
                                         grade[3]
                                                     90
                                                          0012FF70
                                                     3
                                                          0012FF74
                                          counter
                                                    150
                                                          0012FF78
                                               sum
```

```
int sum{ 0 };
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                          0012FF60
                                          average
   sum += grade[ counter ];
                                         grade[0]
                                                          0012FF64
}
int average{ sum / 3 };
                                         grade[1]
                                                     70
                                                          0012FF68
                                         grade[2]
                                                     80
                                                          0012FF6C
                                         grade[3]
                                                     90
                                                          0012FF70
                                                     3
                                                          0012FF74
                                          counter
                                                    240
                                                          0012FF78
                                               sum
```

```
int sum{ 0 };
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                          0012FF60
                                          average
   sum += grade[ counter ];
                                         grade[0]
                                                          0012FF64
}
int average{ sum / 3 };
                                         grade[1]
                                                     70
                                                          0012FF68
                                         grade[2]
                                                     80
                                                          0012FF6C
                                         grade[3]
                                                     90
                                                          0012FF70
                                                          0012FF74
                                          counter
                                                     4
                                                    240
                                                          0012FF78
                                               sum
```

```
int sum{ 0 };
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                          0012FF60
                                          average
                                                     80
   sum += grade[ counter ];
                                         grade[0]
                                                          0012FF64
}
int average{ sum / 3 };
                                         grade[1]
                                                     70
                                                          0012FF68
                                         grade[2]
                                                     80
                                                          0012FF6C
                                         grade[3]
                                                     90
                                                          0012FF70
                                                          0012FF74
                                          counter
                                                     4
                                                    240
                                                          0012FF78
                                               sum
```

```
#include <iostream>
using namespace std;
int main ()
{
   int grade[ 11 ];
   for( int counter{ 1 }; counter <= 10; ++counter )</pre>
   {
      cout << "Enter grade: ";</pre>
      cin >> grade[ counter ];
   }
   int sum{ 0 };
   for( int i{ 1 }; i <= 3; i++ )
      sum += grade[ i ];
   int average{ sum / 3 }; // average of grades
   cout << "\nThe sum of all 3 grades is " << sum << endl;</pre>
   cout << "Class average is " << average << endl;</pre>
}
```

```
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
{
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                            0012FF64
                                            average
}
                                                            0012FF68
                                                 sum
int sum{ 0 };
                                            counter
                                                            0012FF6C
for( int i{ 1 }; i <= 3; i++ )</pre>
                                                            0012FF70
                                           grade[0]
   sum += grade[ i ];
int average{ sum / 3 };
                                           grade[1]
                                                            0012FF74
                                                            0012FF78
                                           grade[2]
                                           grade[3]
                                                            0012FF7C
```

```
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
{
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                            0012FF64
                                            average
}
                                                            0012FF68
                                                 sum
int sum{ 0 };
                                                            0012FF6C
                                            counter
for( int i{ 1 }; i <= 3; i++ )</pre>
                                                            0012FF70
                                           grade[0]
   sum += grade[ i ];
int average{ sum / 3 };
                                           grade[1]
                                                            0012FF74
                                                            0012FF78
                                           grade[2]
                                           grade[3]
                                                            0012FF7C
```

```
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
{
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                            0012FF64
                                            average
}
                                                            0012FF68
                                                 sum
int sum{ 0 };
                                                            0012FF6C
                                            counter
for( int i{ 1 }; i <= 3; i++ )</pre>
                                                            0012FF70
                                           grade[0]
   sum += grade[ i ];
int average{ sum / 3 };
                                           grade[1]
                                                       70
                                                            0012FF74
                                                            0012FF78
                                           grade[2]
                                           grade[3]
                                                            0012FF7C
```

```
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
{
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                            0012FF64
                                            average
}
                                                            0012FF68
                                                 sum
int sum{ 0 };
                                            counter
                                                            0012FF6C
for( int i{ 1 }; i <= 3; i++ )</pre>
                                                            0012FF70
                                           grade[0]
   sum += grade[ i ];
int average{ sum / 3 };
                                           grade[1]
                                                       70
                                                            0012FF74
                                                            0012FF78
                                           grade[2]
                                           grade[3]
                                                            0012FF7C
```

```
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
{
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                            0012FF64
                                            average
}
                                                            0012FF68
                                                 sum
int sum{ 0 };
                                            counter
                                                            0012FF6C
for( int i{ 1 }; i <= 3; i++ )</pre>
                                                            0012FF70
                                           grade[0]
   sum += grade[ i ];
int average{ sum / 3 };
                                           grade[1]
                                                       70
                                                            0012FF74
                                           grade[2]
                                                       80
                                                            0012FF78
                                           grade[3]
                                                            0012FF7C
```

```
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
{
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                            0012FF64
                                            average
}
                                                            0012FF68
                                                 sum
int sum{ 0 };
                                            counter
                                                            0012FF6C
for( int i{ 1 }; i <= 3; i++ )</pre>
                                                            0012FF70
                                           grade[0]
   sum += grade[ i ];
int average{ sum / 3 };
                                           grade[1]
                                                       70
                                                            0012FF74
                                           grade[2]
                                                       80
                                                            0012FF78
                                           grade[3]
                                                            0012FF7C
```

```
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
{
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                            0012FF64
                                            average
}
                                                            0012FF68
                                                 sum
int sum{ 0 };
                                            counter
                                                            0012FF6C
for( int i{ 1 }; i <= 3; i++ )</pre>
                                                            0012FF70
                                           grade[0]
   sum += grade[ i ];
int average{ sum / 3 };
                                           grade[1]
                                                       70
                                                            0012FF74
                                           grade[2]
                                                       80
                                                            0012FF78
                                                            0012FF7C
                                           grade[3]
                                                       90
```

```
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
{
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                            0012FF64
                                            average
}
                                                            0012FF68
                                                 sum
int sum{ 0 };
                                                            0012FF6C
                                            counter
for( int i{ 1 }; i <= 3; i++ )</pre>
                                                            0012FF70
                                           grade[0]
   sum += grade[ i ];
int average{ sum / 3 };
                                           grade[1]
                                                       70
                                                            0012FF74
                                           grade[2]
                                                       80
                                                            0012FF78
                                                            0012FF7C
                                           grade[3]
                                                       90
```

```
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
{
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                            0012FF64
                                            average
}
                                                       70
                                                            0012FF68
                                                 sum
int sum{ 0 };
                                            counter
                                                            0012FF6C
for( int i{ 1 }; i <= 3; i++ )</pre>
                                                            0012FF70
                                           grade[0]
   sum += grade[ i ];
int average{ sum / 3 };
                                           grade[1]
                                                       70
                                                            0012FF74
                                           grade[2]
                                                       80
                                                            0012FF78
                                                            0012FF7C
                                           grade[3]
                                                       90
```

```
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
{
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                            0012FF64
                                            average
}
                                                       150
                                                            0012FF68
                                                 sum
int sum{ 0 };
                                            counter
                                                            0012FF6C
for( int i{ 1 }; i <= 3; i++ )</pre>
                                                            0012FF70
                                           grade[0]
   sum += grade[ i ];
int average{ sum / 3 };
                                           grade[1]
                                                       70
                                                            0012FF74
                                           grade[2]
                                                       80
                                                            0012FF78
                                                            0012FF7C
                                           grade[3]
                                                       90
```

```
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
{
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                            0012FF64
                                            average
}
                                                      240
                                                            0012FF68
                                                 sum
int sum{ 0 };
                                            counter
                                                            0012FF6C
for( int i{ 1 }; i <= 3; i++ )</pre>
                                                            0012FF70
                                           grade[0]
   sum += grade[ i ];
int average{ sum / 3 };
                                           grade[1]
                                                       70
                                                            0012FF74
                                           grade[2]
                                                       80
                                                            0012FF78
                                                            0012FF7C
                                           grade[3]
                                                       90
```

```
int grade[ 4 ];
for( int counter{ 1 }; counter <= 3; ++counter )</pre>
{
   cout << "Enter grade: ";</pre>
   cin >> grade[ counter ];
                                                            0012FF64
                                            average
                                                       80
}
                                                      240
                                                            0012FF68
                                                 sum
int sum{ 0 };
                                                            0012FF6C
                                            counter
for( int i{ 1 }; i <= 3; i++ )</pre>
                                                            0012FF70
                                           grade[0]
   sum += grade[ i ];
int average{ sum / 3 };
                                           grade[1]
                                                       70
                                                            0012FF74
                                           grade[2]
                                                       80
                                                            0012FF78
                                                            0012FF7C
                                           grade[3]
                                                       90
```

```
#include <iostream>
                               Indefinite Repetition
using namespace std;
int main ()
{
   int grade;
   int sum{ 0 };
   int counter{ 0 };
   cout << "Enter grade: ";</pre>
   while( cin >> grade )
      sum += grade;
      ++counter;
      cout << "Enter grade: ";</pre>
   }
   int average{ sum / counter }; // average of grades
   cout << "\nThe sum of all " << counter << " grades is "</pre>
        << sum << endl:
   cout << "Class average is " << average << endl;</pre>
}
```

Indefinite Repetition

Using the End-Of-File (EOF) which is Ctrl+Z for windows to stop the reading from standard input.

```
int n;
while( cin >> n )
   cout << n << endl;</pre>
```

ci n >> n returns false when encounters End-Of-File.

Enter grade: 75

Enter grade: 94

Enter grade: 97

Enter grade: 88

Enter grade: 70

Enter grade: 64

Enter grade: 83

Enter grade: 89

Enter grade: ^Z

The sum of all 8 grades is 660

Class average is 82

Sentinel-Controlled Repetition

- Let's generalize the class average problem
 - Develop a class-averaging program that will process an arbitrary number of grades each time the program is run.
- The program must process an arbitrary number of grades.
 - How can the program determine when to stop the input of grades?
- Can use a special value called a sentinel value (also called a signal value, a dummy value or a flag value) to indicate "end of data entry."
- The sentinel value must not be an acceptable input value

```
Enter grade or -1 to quit: 75
Enter grade or -1 to quit: 94
Enter grade or -1 to quit: 97
Enter grade or -1 to quit: 88
Enter grade or -1 to quit: 70
Enter grade or -1 to quit: 64
Enter grade or -1 to quit: 83
Enter grade or -1 to quit: 89
Enter grade or -1 to quit: -1
```

Total of all 8 grades entered is 660 Class average is 82.50

```
#include <iostream>
#include <i omanip>
using namespace std;
int main()
{
   int grade;
   int sum{ 0 };
   int counter{ 0 };
   while( grade != -1 )
   {
      cout << "Enter grade or -1 to quit: ";</pre>
      cin >> grade;
      sum += grade;
      ++counter;
   int average{ sum / counter }; // average of grades
   cout << "\nThe sum of all " << counter << " grades is "</pre>
        << sum << endl;</pre>
   cout << "Class average is " << average << endl;</pre>
}
```

```
#include <iostream>
#include <i omanip>
using namespace std;
int main()
{
   int grade;
   int sum{ 0 };
   int counter{ 0 };
   cout << "Enter grade or -1 to quit: ";</pre>
   cin >> grade;
   while( grade != -1 )
      sum += grade;
      ++counter;
      cout << "Enter grade or -1 to quit: ";</pre>
      cin >> grade;
   int average{ sum / counter }; // average of grades
   cout << "\nThe sum of all " << counter << " grades is "
        << sum << endl;
   cout << "Class average is " << average << endl;</pre>
}
```

```
#include <iostream>
#include <i omanip>
using namespace std;
int main()
{
   int grade;
   int sum{ 0 };
   int counter{ 0 };
   cout << "Enter grade or -1 to quit: ";</pre>
   cin >> grade;
   while( grade != -1 )
   {
      sum += grade;
      ++counter;
      cout << "Enter grade or -1 to quit: ";</pre>
      cin >> grade;
   }
```

```
Enter grade or -1 to quit: 97
```

Enter grade or -1 to quit: 88

Enter grade or -1 to quit: 72

Enter grade or -1 to quit: -1

Total of all 3 grades entered is 257

Class average is 85.67

Formatting the Floating-Point Numbers

average = 1234.5678;

1234. 567800

```
cout << setprecision( 2 ) << fixed << average << endl;
cout << setprecision( 4 ) << fixed << average << endl;
cout << setprecision( 6 ) << fixed << average << endl;

1234. 56
1234. 5678</pre>
```

Formatting the Floating-Point Numbers

```
average = 1234.5678;
cout << setprecision( 2 ) << average << endl;
cout << setprecision( 4 ) << average << endl;
cout << setprecision( 6 ) << average << endl;
cout << setprecision( 8 ) << average << endl;
cout << setprecision( 10 ) << average << endl;</pre>
```

```
1. 2e+003
1234
1234. 56
1234. 5678
1234. 5678
```

```
Data types
long double (8 bytes) 絕對值範圍大約是 2.2·10-308 ~ 1.8·10<sup>308</sup>
double (8 bytes) 絕對值範圍大約是 2.2·10<sup>-308</sup> ~ 1.8·10<sup>308</sup>
float (4 bytes) 絕對值範圍大約是 1.2·10<sup>-38</sup> ~ 3.4·10<sup>38</sup>
unsigned long long int (unsigned long long) (8 bytes) 0 \sim 2^{64}-1
long long int (long long) (8 bytes) -2^{63} \sim 2^{63}-1
unsigned long int (unsigned long) (4 bytes) 0 \sim 2^{32}-1
long int (long) (4 bytes) -2^{31} \sim 2^{31}-1 (2147483647)
unsigned int (unsigned) (4 bytes) 0 \sim 2^{32}-1 (4294967295)
int (4 bytes) -2^{31} \sim 2^{31}-1 (2147483647)
unsigned short int (unsigned short) (2) 0 \sim 2^{16}-1 (65535)
short int (short) (2 bytes) -2^{15} \sim 2^{15}-1 (32767)
unsi gned char (1 byte) 0 \sim 2^{8}-1 (0 ~ 255)
char (1 byte) -2^7 \sim 2^7 - 1 \ (-128 \sim 127)
bool (1 byte) (false becomes 0, true becomes 1)
```

Fig 5.5 Promotion hierarchy for fundamental data types

```
cin >> maximum;
cin >> number;
if( number > maximum )
         maximum = number;

cin >> number;
if( number > maximum )
         maximum = number;

cin >> number;

cin >> number;

if( number > maximum )
         maximum = number;
```

```
cin >> maxi mum;
cin >> number:
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
```

```
number
0012FF78
0012FF79
0012FF7A
0012FF7B
0012FF7C
0012FF7D
0012FF7D
0012FF7E
```

```
cin >> maxi mum;
for(    ; ; )
{
    cin >> number;
    if( number > maxi mum )
        maxi mum = number;
}
```

```
cin >> maxi mum;
cin >> number:
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
```

```
number
0012FF78
0012FF79
0012FF7A
0012FF7B
0012FF7C
0012FF7D
0012FF7D
0012FF7F
```

```
cin >> maxi mum;
cin >> number:
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
```

```
number
0012FF78
0012FF79
0012FF7A
0012FF7B
0012FF7C
0012FF7D
0012FF7D
0012FF7F
```

```
cin >> maxi mum:
cin >> number:
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
```

```
number
0012FF78
0012FF79
0012FF7A
0012FF7B
0012FF7C
0012FF7D
0012FF7D
0012FF7F
```

```
cin >> maximum;
for( i = 1; i <= 3; i++ )
{
    cin >> number;
    if( number > maximum )
        maximum = number;
}
```

```
cin >> maxi mum:
cin >> number:
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
```

```
number
0012FF78
0012FF79
0012FF7A
0012FF7B
0012FF7C
0012FF7C
0012FF7D
0012FF7D
0012FF7F
```

```
cin >> maximum;
for( i = 1; i <= 3; i++ )
{
    cin >> number;
    if( number > maximum )
        maximum = number;
}
```

```
cin >> maxi mum;
cin >> number:
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
```

```
\begin{array}{c} & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\
```

```
cin >> maximum;
for( i = 1; i <= 3; i++ )
{
    cin >> number;
    if( number > maximum )
        maximum = number;
}
```

```
cin >> maxi mum;
cin >> number:
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
```

```
\begin{array}{c|c} & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\
```

```
cin >> maximum;
for( i = 1; i <= 3; i++ )
{
    cin >> number;
    if( number > maximum )
        maximum = number;
}
```

```
cin >> maxi mum:
cin >> number:
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
cin >> number;
if( number > maxi mum )
    maxi mum = number;
```

```
\begin{array}{c} & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\
```

```
cin >> maximum;
for( i = 1; i <= 3; i++ )
{
    cin >> number;
    if( number > maximum )
        maximum = number;
}
```

```
cin >> maxi mum;
cin >> number;
if( number > maxi mum )
    maxi mum = number;

cin >> number;
if( number > maxi mum )
    maxi mum = number;

cin >> number;
if( number > maxi mum )
    maxi mum = number;
```

```
\begin{array}{c} & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\
```

```
cin >> maximum;
for( i = 1; i <= 3; i++ )
{
    cin >> number;
    if( number > maximum )
        maximum = number;
}
```

```
cin >> maximum;
cin >> number;
if( number > maximum )
    maximum = number;

cin >> number;
if( number > maximum )
    maximum = number;

cin >> number;
if( number > maximum )
    maximum = number;
```

```
\begin{array}{c} & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\
```

```
cin >> maximum;
for( i = 1; i <= 3; i++ )
{
    cin >> number;
    if( number > maximum )
        maximum = number;
}
```

Write a program that uses for statements to print the following pattern. All asterisks (*) should be printed by a single statement of the form cout << '*';

*

**

* * *

* * * *

```
int main()
   for( int column{ 1 }; column <= 1; column++ )</pre>
      cout << "*";
   cout << endl;
   for( int column{ 1 }; column <= 2; column++ )</pre>
      cout << "*";
   cout << endl;
   for( int column{ 1 }; column <= 3; column++ )</pre>
      cout << "*";
   cout << endl;
   for( int column{ 1 }; column <= 4; column++ )</pre>
      cout << "*";
   cout << endl:
```

```
int main()
{
    for( int row{ 1 }; row <= 4; row++ )
    {
       for( int column{ 1 }; column <= row; column++ )
          cout << "*";
       cout << endl;
    }
}</pre>
```

Write a program that uses for statements to print the following pattern. All asterisks (*) should be printed by a single statement of the form cout << '*';

```
***
```

* * *

**

*

```
int main()
{
   for( int column{ 1 }; column <= 4; column++ )</pre>
      cout << "*";
   cout << endl;
   for( int column{ 1 }; column <= 3; column++ )</pre>
      cout << "*";
   cout << endl;
   for( int column{ 1 }; column <= 2; column++)
      cout << "*";
   cout << endl;
   for( int column{ 1 }; column <= 1; column++ )</pre>
      cout << "*";
   cout << endl;
}
```

```
int main()
{
    for( int row = 4; row >= 1; row-- )
    {
        for( int column{ 1 }; column <= row; column++ )
            cout << "*";
        cout << endl;
    }
}</pre>
```

Characters

```
0012FF40
                 ch1: 3
                                                          0012FF41
                 ch2: 5
                 ch1: 51
                                                          0012FF42
                 ch2: 53
                                               00110111
                                                          0012FF43
                                          ch2
                                                                      5
                 ch1 + ch2: 104
                                                          0012FF44
                                                          0012FF45
                       Output
int main()
                                                          0012FF46
{
                                          ch1
                                               00110011
                                                          0012FF47
   char ch1 = '3';
   char ch2 = '5';
   cout << "ch1: " << ch1 << endl;
   cout << "ch2: " << ch2 << endl;
   cout << "ch1: " << static_cast< int >( ch1 ) << endl;</pre>
   cout << "ch2: " << static_cast< int >( ch2 ) << endl;</pre>
   cout << "ch1 + ch2: " << ch1 + ch2 << endl << endl;
}
```

Characters

```
0012FF40
                  ch1: +
                                                           0012FF41
                  ch2: -
                  ch1: 43
                                                           0012FF42
                  ch2: 45
                                                00101101
                                                           0012FF43
                                           ch2
                  ch1 + ch2: 88
                                                           0012FF44
                                                           0012FF45
                       Output
int main()
                                                           0012FF46
{
                                           ch1
                                                00101011
                                                           0012FF47
   char ch1 = '+';
   char ch2 = '-';
   cout << "ch1: " << ch1 << endl;
   cout << "ch2: " << ch2 << endl;</pre>
   cout << "ch1: " << static_cast< int >( ch1 ) << endl;</pre>
   cout << "ch2: " << static_cast< int >( ch2 ) << endl;</pre>
   cout << "ch1 + ch2: " << ch1 + ch2 << endl << endl;
}
```

ASCII character set										
	0	1	2	3	4	5	6	7	8	9
0	nul	soh	stx	etx	eot	enq	ack	bel	bs	ht
1	nl	vt	ff	cr	S0	si	dl e	dc1	dc2	dc3
2	dc4	nak	syn	etb	can	em	sub	esc	fs	gs
3	rs	us	sp	!	11	#	\$	%	&	1
4	()	*	+	,	-		/	0	1
5	2	3	4	5	6	7	8	9	:	;
6	<	=	>	?	@	A	В	С	D	E
7	F	G	Н	I	J	K	L	M	N	0
8	P	Q	R	S	T	U	V	W	X	Y
9	Z	[\]	^	_	1	a	b	С
10	d	e	f	g	h	i	j	k	1	m
11	n	О	p	q	r	S	t	u	V	w
12	X	y	Z	{		}	~	del		

0 00	0000000	16						1
		16	00010000	32	00100000	48	00110000	0
1 00	0000001	17	00010001	33	00100001	49	00110001	1
2 00	0000010	18	00010010	34	00100010	50	00110010	2
3 00	0000011	19	00010011	35	00100011	51	00110011	3
4 00	0000100	20	00010100	36	00100100	52	00110100	4
5 00	0000101	21	00010101	37	00100101	53	00110101	5
6 00	0000110	22	00010110	38	00100110	54	00110110	6
7 00	0000111	23	00010111	39	00100111	55	00110111	7
8 00	0001000	24	00011000	40	00101000	56	00111000	8
9 00	0001001	25	00011001	41	00101001	57	00111001	9
10 00	0001010	26	00011010	42	00101010	58	00111010	
11 00	0001011	27	00011011	43	00101011	59	00111011	
12 00	0001100	28	00011100	44	00101100	60	00111100	
13 00	0001101	29	00011101	45	00101101	61	00111101	
14 00	0001110	30	00011110	46	00101110	62	00111110	
15 00	0001111	31	00011111	47	00101111	63	00111111	

					ı						
64	01000000	8	30	01010000	P	96	01100000		112	01110000	p
65	01000001	A 8	31	01010001	Q	97	01100001	a	113	01110001	\mathbf{q}
66	01000010	В 8	32	01010010	R	98	01100010	b	114	01110010	r
67	01000011	C 8	33	01010011	S	99	01100011	C	115	01110011	s
68	01000100	D 8	34	01010100	T	100	01100100	d	116	01110100	t
69	01000101	E 8	35	01010101	U	101	01100101	e	117	01110101	u
70	01000110	F 8	36	01010110	V	102	01100110	f	118	01110110	v
71	01000111	G 8	37	01010111	W	103	01100111	g	119	01110111	w
72	01001000	Н 8	88	01011000	X	104	01101000	h	120	01111000	X
73	01001001	I 8	39	01011001	Y	105	01101001	i	121	01111001	y
74	01001010	J 9	90	01011010	Z	106	01101010	j	122	01111010	Z
75	01001011	K S	91	01011011		107	01101011	k	123	01111011	
76	01001100	L 9	92	01011100		108	01101100	1	124	01111100	
77	01001101	M S	93	01011101		109	01101101	m	125	01111101	
78	01001110	N S	94	01011110		110	01101110	n	126	01111110	
79	01001111	0 9	95	01011111		111	01101111	o	127	01111111	
		•			•						•

- Character constant
 - Enclosed in single quotes,
 - for example: 'z'
- A string is a series of characters treated as a single unit.
 - May include letters, digits and various special characters such as
 +, -, *, / and \$.
- A string is an array of characters ending with a null character
 ('\0')
- String
 - Enclosed in double quotes,
 - for example: "I like C++"

- All strings end with null (' \0')
- Character array

```
char color[ 5 ] = "blue";
```

- Creates 5 element char array col or
- Null character ('\0') implicitly added
- Alternative for character array

```
char color[5] = { 'b', 'l', 'u', 'e', '\setminus0'};
```

- All strings end with null (' \0')
- Character array

```
char color[] = "blue";
```

- Creates 5 element char array col or
- Null character ('\0') implicitly added
- Alternative for character array

```
char color[] = \{ 'b', 'l', 'u', 'e', '\setminus 0' \};
```

						color[0]	b	0012FF48
	0	1	2	3	4	color[1]	1	0012FF49
color	b	1	u	e	\0	color[2]	u	0012FF4A
		-				color[3]	e	0012FF4B
						color[4]	\0	0012FF4D

Input from keyboard

```
char color[ 10 ];
cin >> color;
```

- Puts user input in string
 - Stops at first whitespace character
 - Adds nul 1 character
- If too much text entered, run time error
- Printing strings

```
cout << color << endl;</pre>
```

- Does not work for other array types
- Characters printed until **null** found

```
#include <iostream>
using namespace std;
int main()
   char string1[ 20 ];
   char string2[] = "happy new year";
   cout << "Enter the string \"merry christmas\": ";</pre>
   cin >> string1; // reads "merry"
   cout << "string1 is: " << string1 << "\nstring2 is: " << string2;</pre>
   cout << "\nstring1 with spaces between characters is: \n";</pre>
   for ( int i = 0; string1[ i ] != ' \setminus 0'; i++ )
      cout << string1[ i ] << ' ';</pre>
   cin >> string1; // reads "christmas"
   cout << "\nstring1 is: " << string1 << endl;</pre>
```

```
Enter the string "merry christmas": merry christmas string1 is: merry string2 is: happy new year string1 with spaces between characters is: m e r r y string1 is: christmas
```

	0	1	2	3	4	5	6	7	8	9	
s1											

s1[0]		0012FF48
s1[1]		0012FF49
s1[2]		0012FF4A
s1[3]		0012FF4B
s1[4]		0012FF4C
s1[5]		0012FF4D
s1[6]		0012FF4E
s1[7]		0012FF4F
s1[8]		0012FF50
s1[9]		0012FF51
	s1[1] s1[2] s1[3] s1[4] s1[5] s1[6] s1[7] s1[8]	s1[1] s1[2] s1[3] s1[4] s1[5] s1[6] s1[7] s1[8]

s1[0]	m	0012FF48
s1[1]	e	0012FF49
s1[2]	r	0012FF4A
s1[3]	r	0012FF4B
s1[4]	y	0012FF4C
s1[5]	\0	0012FF4D
s1[6]		0012FF4E
s1[7]		0012FF4F
s1[8]		0012FF50
s1[9]	·	0012FF51
	s1[1] s1[2] s1[3] s1[4] s1[5] s1[6] s1[7] s1[8]	s1[1] e s1[2] r s1[3] r s1[4] y s1[5] \0 s1[6] s1[7] s1[8] s1[8]

int main()	s1[0]	C	0012FF48
{ char s1[10];	s1[1]	h	0012FF49
	s1[2]	r	0012FF4A
cin >> s1; // reads "merry"	s1[3]	i	0012FF4B
cout << "s1 is: " << s1;	s1[4]	S	0012FF4C
<pre>for(int i{ 0 }; s1[i] != '\0'; i++)</pre>	s1[5]	t	0012FF4D
cout << s1[i] << ' ';	s1[6]	m	0012FF4E
cin >> s1; // reads "christmas"	s1[7]	a	0012FF4F
cout << "\ns1 is: " << s1 << endl;	s1[8]	S	0012FF50
}	s1[9]	/0	0012FF51

```
0012FF48
                                                            s1[0]
                                                                      h
                                                                          0012FF49
                                                            s1[1]
                                                                      a
                                                                          0012FF4A
                                                            s1[2]
                                                                      p
                                                             s1[3]
                                                                          0012FF4B
                                                                      p
           2
               3
                  4
                      5
                          6
                             7
                                 8
                                    9
                                        10 11 12 13 14
                                                                          0012FF4C
                                                             s1[4]
                                                                      y
s2
                                                      /0
        a
                             \mathbf{e}
                                 W
                                        y
                                            \mathbf{e}
                                               a
                                                   r
           p
               p
                  y
                          n
                                                             s1[5]
                                                                          0012FF4D
                                                                          0012FF4E
                                                             s1[6]
                                                                      n
      int main()
                                                             s1[7]
                                                                          0012FF4F
                                                                      \mathbf{e}
      {
                                                            s1[8]
                                                                          0012FF50
                                                                      W
         char s2[] = "happy new year";
                                                            s1[9]
                                                                          0012FF51
         cout << "s2 is: " << s2;
                                                           s1[10]
                                                                          0012FF52
                                                                      y
      }
                                                                          0012FF53
                                                           s1[11]
                                                                      \mathbf{e}
                                                           s1[12]
                                                                          0012FF54
                                                                      a
                                                                          0012FF55
                                                           s1[13]
                                                                      r
                                                                     \0
                                                                          0012FF56
                                                           s1[14]
```

$$A \to 10$$
 台北市 $J \to 18$ 新竹縣 $S \to 26$ 高雄縣 $B \to 11$ 台中市 $K \to 19$ 苗栗縣 $T \to 27$ 屏東縣 $C \to 12$ 基隆市 $L \to 20$ 台中縣 $U \to 28$ 花蓮縣 $D \to 13$ 台南市 $M \to 21$ 南投縣 $V \to 29$ 台東縣 $E \to 14$ 高雄市 $N \to 22$ 彰化縣 $W \to 32$ 金門縣 $F \to 15$ 台北縣 $O \to 35$ 新竹市 $X \to 30$ 澎湖縣 $G \to 16$ 宜蘭縣 $P \to 23$ 雲林縣 $Y \to 31$ 陽明山 $H \to 17$ 桃園縣 $Q \to 24$ 嘉義縣 $Z \to 33$ 連江縣 $A \to 34$ 嘉義市 $A \to 25$ 台南縣

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- (2) 此數字之個位數乘以9再加十位數
- (3) 第二碼到第九碼依次乘以8、7、・・・、2、1
- (4) 求(2)與(3)之和
- (5) 若(4)為10的倍數則第十碼為0,否則,第十碼為10減[(4)除以10之餘數]

```
A \rightarrow 10 台北市 J \rightarrow 18 新竹縣
                                           S \rightarrow 26
                                                      高雄縣
B \rightarrow 11 台中市 K \rightarrow 19 苗栗縣
                                       T \rightarrow 27
                                                      屏東縣
C \rightarrow 12 基隆市 L \rightarrow 20 台中縣 U \rightarrow 28
                                                      花蓮縣
                                                      台東縣
D \rightarrow 13 台南市 M \rightarrow 21 南投縣 V \rightarrow 29
E \rightarrow 14 高雄市 N \rightarrow 22 彰化縣 W \rightarrow 32
                                                      金門縣
F \rightarrow 15 台北縣 O \rightarrow 35 新竹市 X \rightarrow 30
                                                      澎湖縣
G \rightarrow 16 宜蘭縣 P \rightarrow 23 雲林縣 Y \rightarrow 31
                                                      陽明山
H \rightarrow 17 桃園縣 Q \rightarrow 24 嘉義縣 Z \rightarrow 33 連江縣
I → 34 嘉義市
                 R → 25 台南縣
```

$$A \to 10$$
 台北市 $J \to 18$ 新竹縣 $S \to 26$ 高雄縣 $B \to 11$ 台中市 $K \to 19$ 苗栗縣 $T \to 27$ 屏東縣 $C \to 12$ 基隆市 $D \to 13$ 台南市 $D \to 13$ 台南市 $D \to 13$ 台南市 $D \to 14$ 高雄市 $D \to 15$ 台北縣 $D \to 15$ 白南縣

	0	1	2	3	4	5	6	7	8	9	10	11	12
firstChar	10	11	12	13	14	15	16	17	34	18	19	20	21

13	14	15	16	17	18	19	20	21	22	23	24	25
22	35	23	24	25	26	27	28	29	32	30	31	33

```
int main()
{
   int firstChar[ 26 ] = { 10, 11, 12, 13, 14, 15, 16, 17, 34, 18,
                           19, 20, 21, 22, 35, 23, 24, 25, 26, 27,
                           28, 29, 32, 30, 31, 33 };
   char id[ 11 ] = "";
   cout << "Enter the first 9 characters of an id number: ";
   cin >> id:
   int leadingNumber;
   if(id[0]) >= 'A' && id[0] <= 'Z')
     leadingNumber = firstChar[ id[ 0 ] - 'A' ];
   if(id[0]) >= 'a' \&\& id[0] <= 'z')
      leadingNumber = firstChar[ id[ 0 ] - 'a' ];
   int sum = ( leadingNumber % 10 ) * 9 + ( leadingNumber / 10 );
   for( int i{ 1 }; i <= 8; i++ )
      sum += (id[i] - '0') * (9 - i);
   if( sum % 10 != 0 )
     id[9] = 10 - (sum \% 10) + '0';
   cout << "\nThe corresponding id number is " << id << endl << endl;</pre>
```

i d[0]	01000011	0012FF48	C	67
i d[1]	00110001	0012FF49	1	49
i d[2]	00110010	0012FF4A	2	50
i d[3]	00110000	0012FF4B	0	48
i d[4]	00110000	0012FF4C	0	48
i d[5]	00110101	0012FF4D	5	53
i d[6]	00110111	0012FF4E	7	55
i d[7]	00110010	0012FF4F	2	50
i d[8]	00110001	0012FF50	1	49
i d[9]	00000000	0012FF51	\0	0
i d[10]	00000000	0012FF52	\0	0
•		=		

```
if(id[0]) >= 'A' && id[0] <= 'Z')
          leadingNumber = firstChar[ id[ 0 ] - 'A' ];
              1
                      3
            0
                   2
                             5
                                6
                                    7
                                       8
                                           9
                                             10 11 12
                         4
firstChar | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 34 | 18 | 19 | 20 | 21
            13 14 15 16 17 18 19 20 21 22 23 24 25
              35 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
                                             30 31 33
           22
                                          32
              i d[0]
                      01000011
                                  0012FF48
                                                   67
              i d[1]
                      00110001
                                  0012FF49
                                                   49
              i d[2]
                      00110010
                                  0012FF4A
                                               2
                                                    50
                      00110000
                                  0012FF4B
              i d[3]
                                               0
                                                   48
                      00110000
                                  0012FF4C
              i d[4]
                                                   48
                                               0
              i d[5]
                      00110101
                                  0012FF4D
                                               5
                                                   53
              i d[6]
                      00110111
                                  0012FF4E
                                               7
                                                    55
                      00110010
              i d[7]
                                  0012FF4F
                                               2
                                                    50
              i d[8]
                      00110001
                                  0012FF50
                                               1
                                                   49
              id[9]
                      0000000
                                  0012FF51
                                              \0
                                                    0
                      0000000
                                  0012FF52
                                                    0
             i d[10]
                                              /0
```

```
if(id[0]) >= 'A' && id[0] <= 'Z')
          leadingNumber = firstChar[ id[ 0 ] - 'A' ];
              1
                      3
            0
                   2
                             5
                                6
                                    7
                                       8
                                           9
                                             10 11 12
                          4
firstChar | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 34 | 18 | 19 | 20 | 21
            13 14 15 16 17 18 19 20 21 22 23 24 25
               35 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
                                             30 31 33
           22
                                          32
              i d[0]
                      01000011
                                  0012FF48
                                                    67
              i d[1]
                      00110001
                                  0012FF49
                                                    49
              i d[2]
                      00110010
                                  0012FF4A
                                               2
                                                    50
                                  0012FF4B
              i d[3]
                      00110000
                                               0
                                                    48
                      00110000
                                  0012FF4C
              i d[4]
                                                    48
                                               0
              i d[5]
                      00110101
                                  0012FF4D
                                               5
                                                    53
              i d[6]
                      00110111
                                  0012FF4E
                                               7
                                                    55
              i d[7]
                      00110010
                                  0012FF4F
                                               2
                                                    50
                      00110001
              i d[8]
                                  0012FF50
                                               1
                                                    49
              id[9]
                      00110011
                                  0012FF51
                                               3
                                                    51
                      0000000
                                  0012FF52
             i d[10]
                                               \0
                                                    0
```

break and continue Statements

```
int main()
{
   int i;
   bool isPrime = true;
   cout << "Enter an integer greater than 1: ";</pre>
   cin >> i;
   for(int j = 2; j < i; j++)
      if(
      {
      }
   cout << endl << i << " is ";
   if( !isPrime )
      cout << "not ";</pre>
   cout << "a prime number\n\n";</pre>
}
```

```
int main()
{
   int i;
   bool isPrime = true;
   cout << "Enter an integer greater than 1: ";</pre>
   cin >> i;
   for( int j = 2; j < i; j ++)
      if((i\% j) == 0)
      {
         isPrime = false;
          break;
      }
   cout << endl << i << " is ";
   if( !isPrime )
      cout << "not ";</pre>
   cout << "a prime number\n\n";</pre>
}
```

```
#include <iostream>
using namespace std;
int main()
   for( int i = 1; i \le 20; i++)
      if(i \% 3 == 0)
         continue;
      cout << i << " ";
   cout << "\nUsed continue to skip multiples of 3\n";</pre>
```

1 2 4 5 7 8 10 11 13 14 16 17 19 20 Used continue to skip multiples of 3

switch Multiple-Selection Statement

- The switch multiple-selection statement performs many different actions based on the possible values of a variable or expression.
- Each action is associated with the value of a constant integral expression (i.e., any combination of character and integer constants that evaluates to a constant integer value).

switch Multiple-Selection Statement

```
int main()
{
   int grade;
   int aCount = 0;
   int bCount = 0;
   int cCount = 0;
   int dCount = 0;
   int fCount = 0;
```

```
while (\text{grade} = \text{cin.get}()) != \text{EOF})
{
   if( grade == 'A' || grade == 'a' )
         ++aCount;
   else if( grade == 'B' || grade == 'b' )
         ++bCount:
   else if( grade == 'C' || grade == 'c' )
         ++cCount:
   else if ( grade == 'D' || grade == 'd' )
         ++dCount;
   else if ( grade == 'F' || grade == 'f' )
         ++fCount:
   else if( grade != '\n' && grade != '\t' && grade != ' ')
         cout << "Incorrect letter grade entered."</pre>
               << " Enter a new grade." << endl;</pre>
}
```

```
grade = cin.get();
while( grade != EOF )
   if( grade == 'A' || grade == 'a' )
        ++aCount;
   else if ( grade == 'B' || grade == 'b' )
        ++bCount:
   else if ( grade == 'C' || grade == 'c' )
        ++cCount:
   else if( grade == 'D' || grade == 'd' )
        ++dCount:
   else if( grade == 'F' || grade == 'f' )
        ++fCount;
   else if ( grade != '\n' && grade != '\t' && grade != ' ')
        cout << "Incorrect letter grade entered."</pre>
               << " Enter a new grade. " << endl;</pre>
   grade = cin.get();
```

```
#include <iostream>
using namespace std;
int main()
{
   system( "mode con cols=40 lines=22" );
   system( "color F0" );
   int grade; // letter grade entered by user
   int aCount{ 0 }; // counter of A grades
   int bCount{ 0 }; // counter of B grades
   int cCount{ 0 }; // counter of C grades
   int dCount{ 0 }; // counter of D grades
   int fCount{ 0 }; // counter of F grades
   cout << "Enter the letter grades." << endl</pre>
        << "Enter the EOF character to end input." << endl;</pre>
```

```
Enter the letter grades.
Enter the EOF character to end input.
a
\mathbf{C}
d
\mathbf{f}
E
Incorrect letter grade entered. Enter a new grade.
D
Α
b
^Z
Number of students who received each letter grade:
A: 3
B: 2
C: 3
D:
F: 1
```

```
while ( (grade = cin.get()) != EOF)
{
   switch ( grade )
      case 'A':
      case 'a':
         aCount++;
         break;
      case 'B':
      case 'b':
         bCount++;
         break;
      case 'C':
      case 'c':
         cCount++;
         break;
      case 'D':
      case 'd':
         dCount++;
         break;
      case 'F':
      case 'f':
         fCount++;
         break;
```

```
case '\n':
      case '\t':
      case ' ':
         break;
      default:
          cout << "Incorrect letter grade entered."</pre>
               << " Enter a new grade." << endl;</pre>
         break;
cout << "\n\nNumber of students who received each letter grade: "</pre>
     << "\nA: " << aCount
     << "\nB: " << bCount
     << "\nC: " << cCount
     << "\nD: " << dCount
     << "\nF: " << fCount
     << endl;
```

```
Enter the letter grades.
Enter the EOF character to end input.
a
\mathbf{c}
d
Incorrect letter grade entered. Enter a new grade.
D
b
^Z
Number of students who received each letter grade:
A: 3
B: 2
```

switch Multiple-Selection Statement

- The ci n. get () function reads one character from the keyboard.
- Normally, characters are stored in variables of type char; however, characters can be stored in any integer data type, because types short, i nt and l ong are guaranteed to be at least as big as type char.
- Can treat a character either as an integer or as a character, depending on its use.

Operators Precedence & Associativity

Operator	Associativity
! ++ (post) ++ (pre) + - (unary)	Right to left
* / %	Left to right
+ - (binary)	Left to right
<< >>	Left to right
< <= > >=	Left to right
== !=	Left to right
&&	Left to right
	Left to right
?:	Right to left
= *= /= %= += -=	Right to left